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AGRICULTURAL ENGINEERING

The Journal of the American Society of Agricultural Engineers

JULY 1931

An Explanation of Dynamic Properties of Soils - - - - - - - - - *M. L. Nichols*

Power Requirements of Spray Agitation - - - - - - - - - - - - *K. R. Frost*

Present Status of Mechanical Corn Picking - - - - - - - - - - - *A. L. Young*

Some Observations on Hammer Type Feed Grinders - - - - - - - *William Vutz*

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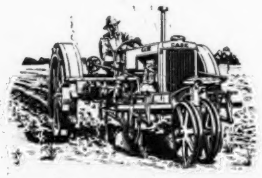

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Volume 12 JULY, 1931 Number 7

CONTENTS

THE PRESIDENT'S ANNUAL ADDRESS 255
By R. W. Trullinger

DOES HIS COLLEGE COURSE FIT THE AGRICULTURAL ENGINEER FOR THE FARM MACHINERY FIELD? 257
By Ralph L. Patty

THE DYNAMIC PROPERTIES OF SOIL—AN EXPLANATION OF THE DYNAMIC PROPERTIES OF SOILS BY MEANS OF COLLOIDAL FILMS 259
By M. L. Nichols

POWER REQUIREMENTS OF SPRAY AGITATION 265
By K. R. Frost

PRESENT STATUS OF MECHANICAL CORN PICKING 267
By A. L. Young

POWER CORN PLANTER ATTACHMENTS 270

SOME OBSERVATIONS ON HAMMER TYPE FEED GRINDERS 271
By William Vutz

THE DESIGN OF GRAIN STORAGE STRUCTURES 274
By J. D. Long

COMPARATIVE EFFECTIVENESS OF HAND AND MECHANICAL CORN PICKING 276
By W. H. Carter

THE DEVELOPMENT OF A CORN COMBINE 277
By C. A. Logan

IRRIGATION IN WESTERN OREGON 279
By M. R. Lewis and Arthur King

AGRICULTURAL ENGINEERING DIGEST 283

EDITORIALS 286

A.S.A.E. AND RELATED ACTIVITIES 287

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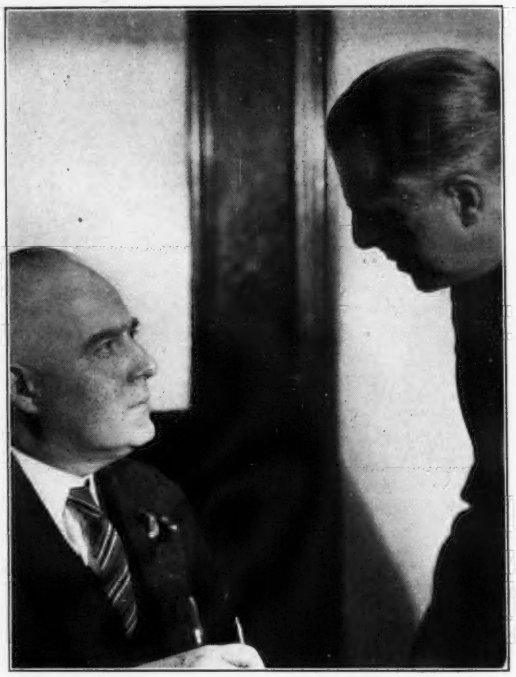

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AGRICULTURAL ENGINEERING

Volume 12 JULY, 1931 Number 7

The President's Annual Address[1]

By R. W. Trullinger[2]

TRADITION dictates that the president of the American Society of Agricultural Engineers shall deliver an address at the annual meeting, which, presumably, shall consist primarily of a summary of the outstanding accomplishments of the Society during the year. Thus tradition embarrasses as well as compliments the president, as it might seem that he is being permitted to summarize those accomplishments of the Society for which he is, to a certain extent, personally responsible. This is far from the case. A president would be presumptuous indeed and in many respects an optimist, to say the least, who would attempt to ascribe any great proportion of the success of the Society to his administration.

R. W. Trullinger

The fact is that the American Society of Agricultural Engineers is now so systematically organized into technical and other divisions and committees, and is so highly coordinated, that its major activities are almost automatic. It is thoroughly and effectively governed by the Council, and its administrative and financial affairs are efficiently taken care of by the Secretary and the national headquarters staff. There is therefore very little for the president to do but look on and marvel at what can be accomplished by an earnest, cooperative body of busy engineers, organized into active and highly coordinated groups according to subject and region. There is less for him to say, as the Society speaks effectively for itself through the activities of its committees and individual members.

The degree of perfection of the Society as regards its organization and the coordination of its activities has been progressive with the years. Your president has observed it for 17 years and recalls quite vividly the struggles of the past to bring order, cooperation, and precise action out of chaos and crossed purposes. In 25 years it has grown from a small but far-seeing and ambitious group of college professors to a great body of engineers in both public and private pursuits. Its activities are international in scope, and its accomplishments are of a continuing character and are making history from day to day. Those accomplishments have grown in magnitude and quality each year, and this is a manifestation of the great momentum of a well-organized Society such as this, which recognizes no obstacles such as economic depressions and the like.

It must be admitted that the Society has experienced an eminently successful year. Much has been accomplished by the four technical divisions, the College Division, and the regional sections under the able leadership of their respective chairmen. Fortunate indeed is the president of this society who has a line-up of divisional, sectional, and committee chairmen such as have occupied these positions during this year.

Power and Machinery Division. Starting out in an auspicious manner this division was early handicapped by necessary changes in the chairmanship. It was not until the year was well advanced that the chairmanship was finally settled for the year. The eminent success of the Division from then on is history. The winter meeting held in Chicago was an indication of the mastery of the situation by the chairman, the vice-chairman, and the committee chairmen of the Division, and bespoke the sincere and purposeful activity of the division members individually and collectively.

The Power and Machinery Division is the largest of the technical divisions of the Society. Its members are men engaged in public service, in consulting practice, and in the manufacture of mechanical equipment. The wonderful spirit of whole-hearted and unselfish cooperation manifested by these men is one of the outstanding features of this division and is typical of the spirit of the Society as a whole. It bespeaks the mutual confidence and respect existing between the men in public service and in the private manufacturing industries. It makes for progress in attaining the common objective of maximum service to the industry of agriculture and removes the barriers of distrust which hindered progress in the earlier years.

The committees of the Division have made notable contributions during the year to the knowledge of tractor fuels and lubricants, soil dynamics, grain and forage drying, corn borer and weed control, tillage machine, combine, and power take-off development, and the like. The progress reported by these committees speaks well for the cooperative spirit prevalent in the Division and is a substantial argument for the slogan "pull together."

Structures Division. This division has labored against numerous handicaps but during this year has made notable progress in attaining its long-sought objective of developing a sound research program in farm structures. The survey of research in farm structures, organized by the Division and carried out by the U. S. Department of Agriculture, has added materially to the accomplishment of the Division in that connection. Special progress has been reported in the design of grain storages and animal shelters. The enthusiastic winter meeting showed that the men specializing in farm structures are developing a soundness of purpose and vision which spells success.

Land Reclamation Division. Under the dynamic leadership of its chairman this division has enjoyed an outstanding year. The midwinter meeting held in conjunction with

[1]Before the 25th annual meeting of the American Society of Agricultural Engineers at Ames, Iowa, June 1931.

[2]Senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture. Mem. ASAE.

It is the obligation of agricultural engineers to contribute to the increased efficiency and prosperity of individual farms, whether small, medium-sized or large, and to their higher standards of civilization

the Pacific Coast Section was a notable success, particularly in the character and quality of the papers and reports presented.

While land reclamation is one of the oldest subjects in agricultural engineering, it bristles with new problems every year. The drainage and irrigation features are gradually being revolutionized into more or less exact practices. The knowledge of land clearing methods and requirements is reaching the point at which explosives manufacturers are designing explosives specially adapted to certain specific agricultural requirements. Notable progress also has been made in the work relating to soil erosion prevention and run-off water control.

The Land Reclamation Division is finding itself and is becoming one of the strongest in the Society. Here again whole-hearted cooperation between the various groups concerned is solving the situation. Too high a tribute cannot be paid to the men who have stuck by the Division in its reverses as well as its successes and are making history in that branch of agricultural engineering relating to the improvement of agricultural lands.

Rural Electric Division. This division also was handicapped at the beginning of the year by changes in the chairmanship. When the responsibility for directing the destinies of the Division was finally settled, the year was well along. In spite of this handicap, things of a notable character have happened in the Division during the year. The high character and quality of these activities are brought out strikingly by the papers and reports presented at this meeting. A notable contribution from the Division was the report on research in rural electrification by G. W. Kable, vice-chairman of the division. Cooperation with the Committee on the Relation of Electricity to Agriculture, which is directed by a member of this Society, has materially strengthened the activities of the Rural Electric Division.

College Division. The College Division is one of the most important in the Society and likewise the one about which probably the least is said. It is a division of hard-working committees as well as individuals. One must attend one of the annual sessions in Washington of the Advisory Committee of the College Division to appreciate and understand the many problems concerned with teaching, extension, research and cooperation which confront the Division. Your president has been fortunate in being permitted to attend these meetings for several years, and the meeting this year was one of outstanding character.

Your president also has been fortunate in that he has been permitted for years to visit the land-grant institutions in the United States where teaching, extension, or research in agricultural engineering is in progress. Some of these institutions have been visited several times. The enthusiasm with which these institutions meet their many and varied problems with all too little finances, facilities and personnel is an inspiration to anyone interested in engineering progress.

The men of the College Division are training the new men in agricultural engineering — the engineers of tomorrow. In the last analysis the responsibility for the future development and success of agricultural engineering and its service to agriculture rests largely with them. The painstaking thoroughness with which students in professional agricultural engineering are being trained today by members of the College Division is gratifying and inspiring.

The research and extension programs in agricultural engineering also are being conducted mainly by the members of the College Division. The development in these lines during the past decade, and especially during the past year, has been little short of remarkable when the relatively meager support available is considered. The research men are virtually pioneers in a new and difficult field where the constant demand is for greater production per man and greater economy and efficiency in production. The extension men are confronted constantly with demands for immediate service, and, in the vernacular, they must "know their stuff." In both instances the responsibility is to serve the agriculture of today as an industry without interfering with the farm as a home for the individual family.

Too high a tribute, therefore, cannot be paid to the men of the College Division at this time. The only regret is that there are not more of them and that they are not better financed and equipped for their work in research and extension and for the training of more and better agricultural engineers.

Bureau of Agricultural Engineering. In connection with the public service features of agricultural engineering, the dream of agricultural engineers of a bureau in the U. S. Department of Agriculture has been realized at last. For years this Society has labored unceasingly through special committees and individual members to have a separate and independent Bureau of Agricultural Engineering established in the Department. These efforts were crowned with success during the year, and on July 1, 1931, the Bureau becomes a reality, with a member and past-president of this Society, Mr. S. H. McCrory, as its chief.

The creation of a Bureau of Agricultural Engineering is a well-merited recognition of the importance which agricultural engineering has assumed in the economics of the agricultural industry. It is an expression of confidence in the agricultural engineering profession on the part of legislators as well as administrators. It provides the facilities for and is a challenge to agricultural engineers to render a better service to agriculture. A bureau such as this is a national agency designed for service of a national character. It must have the whole-hearted cooperation and support of all agricultural engineers whether in public service or private employ.

Medals and Awards. The worth of this Society and the outstanding character of the service being rendered by its individual members to agriculture also was given substantial recognition in as fitting a manner during the year. Through the Committee on Medals and Awards an endowment of $10,000 was received from the McCormick family, to be used as a basic fund for the provision of an annual award of merit to some member of this Society performing a professional service to agriculture of outstanding character. It is gratifying that this substantial

recognition of the efforts of agricultural engineers has come from so distinguished a source.

"Agricultural Engineering." The monthly journal of this Society speaks for itself. Your president may perhaps be permitted a certain amount of pardonable pride in the Journal, since he has been a member of its Publications Committee since 1925. The character and quality of the printed material appearing in its pages have brought forth favorable comment throughout the civilized world. The quality of the advertising in the Journal also merits mention. It may perhaps be well described by the words of the advertising manager of a prominent manufacturer of mechanical equipment who said, "It is worth a lot to appear in distinguished company."

Other Activities. There are numerous other agencies of this Society which merit favorable mention for their outstanding accomplishments during the year. Among these are the committees on research, standards, membership, meetings, and the like. The regional sections of the Society also have been active during the year and have held several outstanding meetings, two of which your president was privileged to attend. The Society also has been represented in national activities of an outstanding character, such as American Engineering Council, Committee on the Relation of Electricity to Agriculture, the Advisory Councils on Research in Mechanical Farm Equipment, Research in Farm Structures and Federal Board of Maps and Surveys, the National Fire Waste Council, and the Joint Committee on Fertilizer Application.

Conclusion. When all is said and done, it would seem that we can be proud of A.S.A.E., not only for what it has accomplished during this year, but for its steady, systematic accomplishment during the quarter-century of its existence. It is truly a society of engineers, for its progress and development are built upon the untiring, systematic, and tenacious service which only engineers can render to an industry.

Through the years the engineers of this Society in both public service and in the manufacturing industries have labored shoulder to shoulder in a quiet and unassuming manner with a common objective. They have learned to work together in harmony and to respect each other. Adhering strictly to the high ideal of rendering service to agriculture, they have contributed to the transformation of agriculture from a means of mere existence to the basis of a high type of civilization.

It seems well especially to consider that fact at this time when the world appears to be laboring under an economic depression. Engineers have been accused of being "magnificent creators of unemployment." Agricultural engineers emphatically deny that statement. It is true that they have systematically reduced the time and labor required in farming operations. However, in so doing they have reduced the cost of production, improved the quality of farm products, and removed a large part of the drudgery from farming. Greater efficiency in farm production has given the farmer more substance with which to secure higher standards of living and more leisure in which to enjoy life. Thus through their untiring efforts agricultural engineers have assisted both directly and indirectly in providing the foundations of a higher civilization in rural communities.

In this connection it must not be forgotten that agricultural engineers are under obligations to agriculture as it is. The greater part of our present agriculture is that which is practiced on small and medium-sized farms. These farms usually are homes as well as means of livelihood, and the prosperity of the regions they inhabit is usually very much dependent upon their prosperity. Therefore, when agricultural engineers contribute to the increased efficiency and prosperity of individual farms, whether small, medium-sized or large, and to their higher standards of civilization, they are contributing indirectly to the prosperity and higher standards of living of the country as a whole.

Let us therefore continue to adhere to our ideals of service to agriculture as it now is. Let us continue to strive for less drudgery and greater efficiency in farming operations. Let us contribute to the fullest extent to the building of the highest attainable standards of civilization on farms and in farming communities as they now exist. Let us continue to be proud of our Society and the profession it represents and be not afraid or backward to tell the world of the ideals as well as the accomplishments of our profession.

Does His College Course Fit the Agricultural Engineer for the Farm Machinery Field?

By Ralph L. Patty[1]

COLLEGE graduates in agricultural engineering are going into the field of farm machinery in greater numbers each year. While this line of work is only one of the outlets for these men, it is a very important one. It is also the line of work which the majority of them seem to prefer when they start the course as freshmen. A survey made at the South Dakota State College supports this statement. During the past two years the boys who have classified in the four-year degree course in agricultural engineering have been canvassed to find out the line of work which they think they would like to follow. Out of 27 boys classifying, 18 have signified "farm machinery and power," so it is evident that students are going to choose this line of work. This means that it is up to the college to so prepare them that they will be most useful to the farm machinery industry.

The agricultural engineer in his college course, like other engineering students, is taught to apply the principles of engineering to his chosen industry, agriculture. The electrical engineer gets his training in general engineering, and then in the electrical engineering department he is given special intensive courses in electrical work. These courses are largely for the purpose of teaching him how to apply his engineering knowledge to the best interest of the electrical industry where he expects to put it into use.

The mining engineer gets his training in general engineering, and then in the mining engineering department he is given his courses in application. These mining engineering courses enable him to use his engineering training most effectively in the mining industry.

The same is true in all lines of engineering including the ceramic engineer, civil engineer, chemical engineer, and so on down through the list including the agricultural engineer. Practically every great industry today has its engineers, men who have a special training which fits them to serve that industry best. This is as it should be, for these men take a greater interest in it. It amounts to a personal interest and a loyalty to their particular industry, first inspired by the work in their particular engineering department in college.

Certainly no one questions the fact that agriculture, the greatest industry of all, needs its engineers today; and farm machinery, power and equipment is one large phase of agricultural engineering work.

Does the agricultural engineer meet the requirements of the farm machinery industry? If he does not, then certainly he should be made to do so. In looking over the

[1]Chairman, department of agricultural engineering, South Dakota State College. Mem. A.S.A.E.

A class of students in the professional agricultural engineering course at South Dakota State College studying farm machinery in operation

curricula for the professional courses in agricultural engineering in the several state colleges and universities, we notice that in pratically every case the full amount of engineering mathematics is required of the agricultural engineer. He is required to take engineering physics and the standard courses in mechanical drawing. Although he does not get as much drawing work as the architectural engineer, his two courses in farm structures design, as required in most colleges, together with machine design and elective courses, brings his training up to par. A further study of the various courses shows that he is getting the work in mechanics of materials, strength of materials, materials of construction, and other engineering subjects that are essential to machinery design and sales. Last but not least, he gets the basic agriculture courses that are essential to him in this work. These include the study of soils, which affect the design of tillage machinery; the study of crops, which affect the design of seeding and harvesting machinery; and the study of feeds, which affect the design of machinery for grinding, chopping, or otherwise preparing feeds for livestock. But what about the courses that teach him to apply these principles of engineering to agriculture?

Farm machinery manufacturers want men who are thoroughly familiar with the parts and principles of farm machines; men who know the materials in the machine part and the principles of its operation. They want men who not only know how to adjust farm machines, but why they are so adjusted; and why one construction is used in preference to another.

After looking over courses of study in agricultural engineering, it would seem that more work in machine design, as applied specifically to farm machines, should be offered. Every course of undergraduate study included a three to five-hour course in farm machinery and from five to ten credit hours of work in farm motors. But most of these cover the adjustment, construction, principles of operation and testing of these machines, with only slight attention given to design and principles of design. It is true that strong courses in this subject are offered as graduate work by some colleges, but few students take graduate work before entering the employ of a farm machinery manufacturer. For graduate work they substitute the experience gained through apprenticeship with the company. It would seem, therefore, that a more thorough undergraduate course in machine design for agricultural engineers would better fit our students for service with the equipment manufacturers.

Last year we discussed this with A. W. Turner[2] representing the farm implement industry, and as a result he has outlined a list of parts and accessories that might be studied in such a course. It was his idea that our college department add to the outline, making it more complete. We have made some additions, but I will submit a portion of his outline just as he furnished it to us. It suggests some thorough and fundamental work applied specifically to farm machines. It covers two years or six quarters of work. The outline for the second and third quarters is as follows:

Second Quarter—
- A. Fastening Devices—bolts, screws, keys, rivets
- B. Structural Details—beams, frames, braces, bearings, (plain, roller, tapered and ball)
- C. Adjusting Devices—levers, latches, sectors, hitches

Third Quarter—
- A. Transmission Devices—belts, chains, clutches, gears, elevating devices, slipping devices, power take-off
- B. Springs—tension, compression, leaf, coil, rake teeth, etc.
- C. Wheels

Most of the above parts are covered more or less in farm machinery courses as they are now given, but in this course they would be taken up intensively and in an organized and methodical manner. Possible duplication would do no harm. As noted, farm motors, including gas engine and tractor studies, are covered more thoroughly in most colleges than field machinery. This would mean that less additional time need be placed on gas engine parts in this course, but all of the courses would be strengthened.

The colleges do not expect to send agricultural engineers out as finished products. Graduates must go through a long apprenticeship of experience and practice before they become really valuable men. The colleges realize this and so do the industries that use these engineers; but with stronger work in the application courses, the time required for them to become valuable to their organizations will be shortened.

[2]Engineer, International Harvester Company. Mem. A.S.A.E.

Machine Production in Agriculture[1]

THE history of agricultural machinery from the beginning of the 19th century reveals that the invention of improved, more efficient equipment has made a marked contribution to the development of civilization. In those countries where machine methods of production have been adopted, the individual agriculturist has been benefitted by increased yields of better quality products through more efficient performance of farm operations. In addition, the use of machinery has made possible the cultivation of a large number of acres per worker. It is in this way that machinery has made its greatest contribution. It has increased the production of the agricultural worker and permitted advancing standards of living to be maintained against competition from countries where wages for hired labor and living conditions among agriculturists have not shown any material advance for centuries.

From the national standpoint, where improvements in agriculture have been secured, they have enabled a decreasing proportion of the people to supply the food and raw materials for an expanding population, and made possible the increased production of other kinds of products, satisfying new wants. The physical production of farm commodities per capita of total population in the United States was no greater in 1919 than in 1879. In this period the total output of manufactured commodities per capita of total population was doubled and that of mining was trebled.

Recent tendencies show an increased application of machinery to agriculture. There is no reason to believe that farm machinery has reached its maximum efficiency, or that the experience of history will not be repeated in the future and a growing mechanization of agriculture be evident. The economy of machine production makes it inevitable.

[1]From "The Economy of Machine Production in Agriculture," by Andrew Stewart, published in "Essays on Canadian Economic Problems," Vol. IV.

The Dynamic Properties of Soil[1]

I. An Explanation of the Dynamic Properties of Soils by Means of Colloidal Films

By M. L. Nichols[2]

AN understanding of the fundamental causes of the reactions of soil to applied force is necessary for the solution of implement-design problems. The explanation most commonly offered for these reactions has been based upon the physics of the film moisture surrounding the soil particles. This has been quite satisfactory from a theoretical viewpoint. It has lacked, however, a quantitave connection with measurements of soil reactions which would permit this theory to be used in the solution of such practical everyday problems as the determination of the draft of tillage implements or the rolling resistance offered by soil to the wheels of agricultural machinery.

Many investigators have attributed the physical properties of soil to its colloidal content. Quantitative as well as qualitative relationships have been indicated, but the relation to practical field problems has usually been merely implied or, in other cases, not carried sufficiently far to point out a casual relationship. This is probably due to the fact that most soil investigators have not been faced with the necessity of obtaining the quantitative relationships which are the basis of engineering design.

This paper sets forth a modification of these views with supporting evidence obtained from studies of the dynamic properties of soil. This viewpoint was obtained from the study of a large volume of data gathered during the last several years. Only summarized results of typical data used as illustrations are included herein.

It was assumed that the reactions of soil to applied force obey some general physical laws which could be used as a basis of tillage implement design. A systematic study of these reactions was undertaken. The properties or reactions were classified and methods evolved for their measurement by the author.[3] The properties considered were (1) resistance to compression, (2) resistance to shear, (3) cohesion, (4) adhesion and (5) frictional resistance. It was assumed that these dynamic properties depended upon (1) particle size, (2) colloidal content, (3) moisture content, (4) organic matter, (5) apparent specific gravity (a measure of structure) and (6) the chemical composition of the colloid. In all of these studies the soil was maintained in an uncemented state and the results were corrected for variations in apparent specific gravity.

In the first studies a series of synthetic soils were used. They were made up by mixing various amounts of Cecil clay with pure sand. It was found that the clay, or colloidal content, and moisture content determined the reactions of these soils. That is, the colloidal content determined the amount of the variation in all reactions and the place on the moisture range at which it occurred. From these data it was tentatively concluded that the film moisture of the very small particles would account for all the variations of these physical reactions.[4] Different field soils were studied and it was found that those with different colloidal contents reacted similarly, but varied in the amount of reaction and the moisture content at which the maximum reaction occurred. A study was then made of the relation between these reactions and a number of single-point soil constants, such as the moisture equivalent and the depression of the freezing point to the dynamic reactions of the soil. It was concluded[5] that while some relationship evidently existed these constants did not give sufficient information to satisfactorily predict the reaction.

Baver[6] working with plastic soils having various colloid contents found that the chemical composition of the colloid and the organic matter varied the location on the moisture range of the Atterberg[7] consistency constants. The constants considered were the lower plastic limit (that moisture percentage at which soil could be rolled into a wire-like formation), the upper plastic limit (that moisture content at which soil would give evidence of flow when jarred by a blow), and the plasticity number (the difference between the upper and lower plastic limits). After studying the methods and results obtained in the study of the dynamic properties of soils, he suggested that as these constants varied with the chemical composition of the colloid they might serve as a ready means of determining the place and amount of the soils' reactions. This relation was investigated[8] with soils of known colloid content, and it was found that these reactions could be predicted from the Atterberg constants.

COLLOID FILM THEORY

It has been stated that the variation of physical reactions of non-plastic soils to applied force was found to depend upon the colloidal content and its moisture relationships. It was also found that the moisture content and amount of the reactions of any plastic soil could be predicted from the Atterberg consistency constants. As the Atterberg constants depend upon colloidal content and its moisture relationships it was apparents that, if the

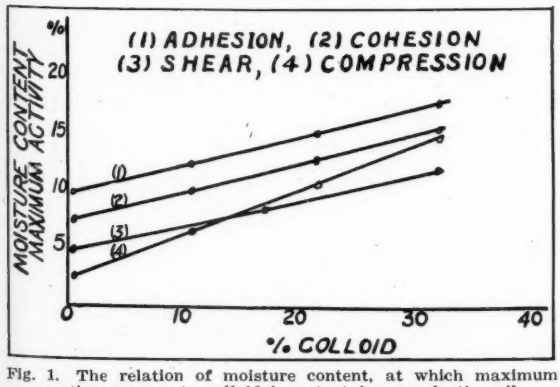


Fig. 1. The relation of moisture content, at which maximum reaction occurs, to colloidal content in non-plastic soils

[1]First of a series of articles setting forth the results of ten years of original research work in soil dynamics at Alabama and released for first publication in AGRICULTURAL ENGINEERING. Polytechnic Institute. Received for publication April 29, 1931.

[2]Agricultural engineer, Alabama Polytechnic Institute, Agricultural Experiment Station. Mem. A.S.A.E.

[3]Nichols, M. L. Methods of Research in Soil Dynamics. Alabama Station Bulletin, No. 229, May, 1929.

[4]Nichols, M. L. The Sliding of Metal Over Soil. AGRICULTURAL ENGINEERING 6: 80-84, 1925.

[5]Nichols, M. L. Annual report to Director, Alabama Experiment Station, July 1, 1929.

[6]Baver, L. D. The Relation of Exchangeable Cations to the Physical Properties of Soil. Journal, American Society of Agronomy, 20: 921-941, 1928.

[7]Atterberg, A. The Plasticity of Clay. Int. Mitt. Fur, Bodenkunde 2: 149-189, 1912.

[8]Nichols, M. L. and Baver, L. D. An Interpretation of the Physical Properties of Soil Affecting Tillage and Implement Design by Means of the Atterberg Consistency Constants. Proceedings of International Soil Congress. Leningrad, Section 1, 1930.

variations on the moisture range could be accounted for, all of these reactions could be explained by means of colloidal content and its moisture relationships. It is quite evident that if this hypothesis be true, the reactions of any soil could be accurately predicted by simple mathematical calculations from the colloidal content.

All of the data obtained during the last seven years were reviewed to see if this hypothesis held. The evidence obtained follows, and includes an explanation of (1) the physics of film moisture, (2) the relationship existing between colloid content and the dynamic properties of non-plastic soils, considering both the amounts of reactions and the moisture contents at which they occur, and (3) the relationships between the colloidal content and the Atterberg consistency constants, which are used as indices to the dynamic properties of plastic soils.

PHYSICS OF FILM ACTION

It was found by Atterberg[9] that only soils having disk or plate-shaped particles evidenced plasticity. Later Baver[10] concluded that the shape of the particle would have a considerable effect on the physical reactions of soil. He attributed plasticity and such reactions as puddling to the orientation of plate-shaped colloidal particles. It is not strictly necessary to assume that colloidal particles have any particular shape in order to establish the validity of evidence that their film moisture is largely responsible for the dynamic properties of soil. The plate-shape of particles, however, best explains the high activity of colloidal material and will be assumed in the following explanations.

The capillary phenomena existing between soil and moisture is quite well understood. Duff[11] explains this as follows: "A film of water between two plate-shaped particles makes it difficult to pull the particles apart by a force normal to their surfaces. The liquid tends to spread over both plates and becomes concave outwards, so that the pressure within is less than the atmospheric pressure which acts on the outside of the plates and this produces an apparent attraction between the plates." The amount of force by which two particles are held together by a capillary film, as explained, may be expressed by the formula

$$F = \frac{K\ 4\ \pi\ R\ T\ \text{Cos}\ a}{D} \qquad [1]$$

where F is the pull, R the radius of the particles, T the surface tension, a the angle of surface contact of the liquid and particles, D the distance apart or amount of water holding the plates apart, and K a constant.

Since a depends upon the attraction of the soil surface for moisture, it would be a constant for one kind of colloid. Also the surface tension, T, would vary but little in any particular soil over a small moisture range. Then, as the size of colloidal particle would not change, the product of force and moisture content for each soil should be practically a constant throughout the moisture range at which all surfaces were saturated but with no excess moisture.

Table I. Relation of Product of Force of Cohesion and Moisture Percentage at Points of Capillary Saturation

Soil	Moisture Content (D) per cent	Cohesion (F) gms. per sq. in.	F x D
Sand, ⅔	10.90	17.25	188
Clay, ⅓	12.90	15.00	192
Sand, ⅓	12.73	26.40	331
Clay, ⅔	13.10	22.50	328
Pure clay	13.55	56.00	860
	17.50	49.00	860

[9]Atterberg, A. The Consistency and Binding Power of Clay. Int. Mitt. Bodenkunde 2: 149-189, 1912.

[10]Baver, L. D. The Atterberg Consistency Constants: Factors Affecting their Values and a New Concept of their Significance. Jour., Am. Soc. of Agronomy 22: 935-948, 1930.

[11]Duff, A. W. A Text Book of Physics. P. Blakiston's Son and Co., Philadelphia.

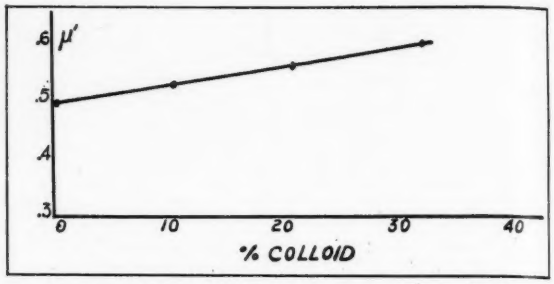


Fig. 2. The relation of colloid to maximum force of adhesion. Adhesion is measured by determining the increased friction due to the "sticking" of a soil to a metal slider

Thus FD would be a constant for any one soil throughout this moisture range, or $F_1 \times D_1$ would equal $F_2 \times D_2$ (Force, F, times distance apart at one moisture percentage, D, would equal force, F_2, times distance apart at another moisture content, D_2.) This is shown in Table I which includes data from three synthetic soils.

NON-PLASTIC SOILS

Moisture Content of Soil for Maximum Reaction. If the variations of the physical reaction of any soil are due to the moisture films of the colloidal content, it follows that the moisture percentage at which maximum reactions occur would be proportional to the colloidal content, as each colloidal particle would have a film of the same or optimum thickness. This would hold only for soils having colloids of the same chemical or absorptive activity, and consequently only data from soils having various amounts of the same kind of colloid will be considered here. These relationships exist as shown in Fig. 1 and were obtained with the four synthetic soils previously described. The term adhesion in this connection indicates the point of maximum pull necessary to slide a piece of plow metal across the soil. This is due to adhesion but is not actually a measure of it. Direct measurement of this property at these moisture contents is practically impossible as its force is greater than the soil's cohesion.

The mathematical formulas for these relationships follow, and were obtained by the method of least squares; M is that moisture content in percentage at which maximum activity occurs, and C is the colloidal content expressed in percentage of soil mass:

	Actual values	Approximate values	
For cohesion, M equals	$0.293C+$	6.94 or $0.3C+$ 7	[2]
For adhesion, M equals	$0.186C+$	10.10 or $0.2C+$10	[3]
For compression, M equals	$0.395C+$	2.10 or $0.4C+$ 2.5	[4]
For shear, M equals	$0.297C+$	4.35 or $0.3C+$ 5	[5]

These formulas were studied to determine the significance of the constants, and it was found that they offered further evidence of the validity of the theory that the variation of the soil's activity was due to colloidal films. This can best be explained by considering the probable reaction of two individual soil particles. When they are held together by a film of moisture the force holding them altogether is expressed by Formula 1. The amount of moisture, D, governs the distance apart of the particles. As the moisture percentage increases, the distance apart increases and the force decreases. It should be noted that the moisture content at which maximum activity occurs is obtained by dividing the total moisture weight by total soil dry weight. The rate of change of total soil moisture expressed in percentage would then vary as the amount of water per unit of colloid. The amount of water per unit of colloid for any given maximum reaction would, however, be the same for all percentages of colloid, or, in other words, the thickness of the films would be constant. That the slope would vary with constant film thickness through all percentages of colloid may be shown mathematically by the formula

$$M = \frac{DC}{100} + b \qquad [6]$$

where M is the moisture of maximum activity expressed in grams per hundred grams of soil, C the amount of colloid, b the intercept of the equation, and D a constant film thickness existing through the equation and having the same value as D in Formula 1. Under these conditions the greater the slope constants, the thicker the films.

The intercept constants in the moisture-place Formulas 2 to 5, inclusive, are, of course, the moisture content of maximum cohesion, shear, adhesion and compression for pure sand. These are all quite evident experimentaly, except that of shear. Tests of shear value for sand indicated that there was a little variation at this point, but it was so small as to be practically negligible.

There are also certain structural changes which must be considered when the colloidal content is increased. In soils having small percentages of colloid it is probably distributed in a large measure over the surfaces of the larger particles. In the case of shear, as will be shown later, this seems to smooth the surface and actually facilitate particle movement, but with cohesion it appears to stick the particles together. In soils having a larger percentage of colloidal material, the colloid appears to be partly grouped into aggregates. Therefore, the combining action and the film thickness must be considered if the slope constants of the above formula are to be explained.

Adhesion takes place when the moisture is so loosely held by the soils surface that the attraction of a foreign body, such as a plow surface, will overcome the cohesive force of the moisture and cause it to spread over the plow surface. This means a relatively high moisture content as the adhesion curve in Fig. 1 shows. The slope constant of the adhesion Formula 3 indicates either a thin colloidal film or a collection of particles into groups which act as units as far as this property is concerned. Since the moisture content throughout the curve is high, the latter is a very logical explanation. Examination of soils under these moisture conditions by means of a low power microscope supports it.

Compression involves an increase of apparent specific gravity brought about by the internal movement of soil particles. Logically this would be expected to be a maximum for a given force when the moisture film is thick and holds the particles with little force. The slope constant indicates that this is the case. The low moisture of sand for maximum compression indicated that sufficient moisture is required to saturate the small amount of colloidal material always present even when the sand had been washed. The moisture content of maximum compression can be better understood when the force of the reaction is considered. This will be considered under quantitative force reactions.

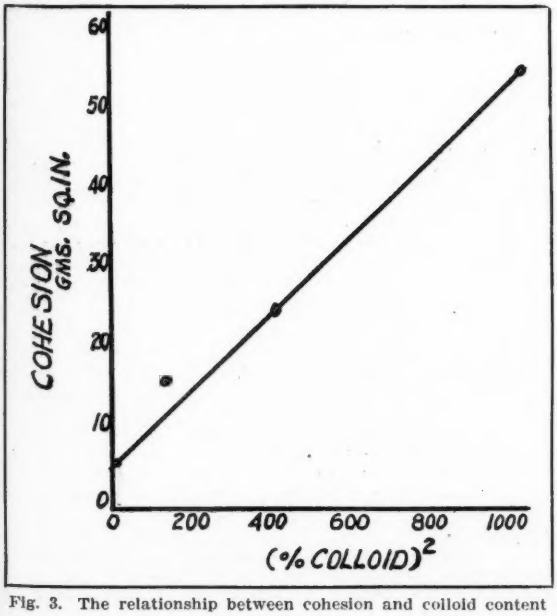


Fig. 3. The relationship between cohesion and colloid content

The amount of moisture for maximum cohesion would be expected to be less than that of adhesion. The slope (Fig. 1) should be slightly greater than that of the adhesion curve, as it would not be due to an excess moisture content above saturation but to the films on the colloidal material itself. The slope also would be expected to be less than that of the curve showing maximum compression points. The intercept constant, i.e., moisture for maximum cohesion of pure sand, would be between that of compression and that of adhesion or at a point where film action was a maximum. The experimental results coincide with these suppositions as shown by the formula.

The moisture content of sand for maximum resistance to shear would be between that of maximum cohesion and that of maximum compression as cohesion and compression both enter into shear of soil. The slope constant should be less than that of either compression or cohesion. When considered on the basis of the force formula (Formula 1) the maximum resistance of internal movement would be expected to occur when cohesion existed, but the films were too thin to act in the manner of a lubricant. Here again the formula supports the film theory.

In a film theory of soil action one would logically expect the moisture films of particles other than colloid to be considered. Apparently from the data these are of very little importance from a soil-reaction standpoint except in the case of pure sand where they gave a slight rigidity to the structure. When considering such properties of pure sand as shear, the moisture films apparently exert no appreciable effect, probably being obscured by other factors. When the tremendous differences in surface between equal weights of sand and colloidal material are considered, it does not appear illogical to disregard the sand. Apparently the surface demand of the colloid is such that it holds the soil's supply of available moisture, when this is limited, and consequently the entire reaction is governed by its films.

Force of Reaction and Colloid Content. The moisture contents at which reactions occur have been shown to vary directly with the colloidal content and to be quite satisfactorily explained by the physical forces of the film moisture on the colloidal particles. If these reactions are due to the films of the colloidal particles, it also follows that the amount of force necessary to produce a given soil reaction would vary with the colloidal content or number of films involved. Cohesion and adhesion being simple reactions which involve merely the breaking of films, should vary directly as the number of colloidal films being broken. Compression and shear, both of which involve orientation of particles, should show a definite relation to colloidal content, but the reactions would not be expected to show a simple, straight line relationship. To eliminate the variation due to chemical or physical absorption (which will be explained under plastic soils) data from the same synthetic soils previously described will be used in the discussion of amount of force involved in these reactions.

Adhesion. The amount of force necessary to pull a piece of plow metal over synthetic soils at the maximum adhesion points is shown by Fig. 2. This shows that the force, expressed as the coefficient of sliding friction, μ', varied directly as the colloidal content. The amount of variation is expressed by the formula

$$F_a = 0.0044\,C + 0.48 \qquad [7]$$

where F_a is the maximum force of adhesion and C is percentage of colloid. In this equation 0.48 is the amount of adhesion of pure sand and 0.0044 is the amount of variation due to one per cent of colloid. Since the publication of this paper will be followed by another dealing with

friction of soil and metal in detail, a detailed discussion here is omitted.

Cohesion. The amount of force of cohesion and its relation to colloidal content for this same series of soils is shown in Fig. 3. The formula expressing this reaction is

$$FC = 0.049\ C^2 + 5 \qquad [8]$$

where the force, FC, is in grams per square inch and C, the colloid, in percentage. In order to show the agreement of this formula with the colloidal film hypothesis, it is necessary to explain the reason for the amount of colloid being squared. To measure the force of cohesion, a given cross-section of soil must be pulled apart. This requires that the soil be packed into the container with sufficient force to insure uniform structure or practically a constant number of films per unit of cross-section area. It was found that a pressure of over ten pounds per square inch was required to give consistent readings. This pressure was applied to all soils in measuring cohesion. It was also found (Table II) with these synthetic soils that the density, or apparent specific gravity, produced by a given pressure varied with the square of the colloid content in accordance with the formula

$$D = 0.0012\ C^2 + 0.5, \qquad [9]$$

where D is the grams increase in density per cubic inch with a given pressure. This was found to be the case regardless of moisture content. It will be readily seen, therefore, that when the force formula is corrected for the amount of colloid, the variation of the force of cohesion is proportional to the amount of colloid present.

Table II. The Relation of Compressibility to Colloidal Content

Soil	Colloidal content—per cent	Variation of compression per cent
Cecil clay	32.0	1.7
Cecil clay ⅔, sand ⅓	21.3	1.1
Cecil clay ⅓, sand ⅔	10.6	0.7
Pure sand	0.1	0.4

Compression. When a soil is compressed, particles of soil must slip past each other or in some manner be rearranged to occpy a smaller volume. When subjected to compressive action the density of the soil mass has been shown to vary with the square of the colloidal content as shown in Table II. Obviously the amount of compression would vary with the density or amount of material occupying a given volume before the pressure was applied. When the results obtained in compression studies were corrected for the density of the soils having been compressed, the amount of compression was found (Fig. 4.) to vary directly with the colloidal content up to a point near where plasticity occurred; from this point the amount of compression varied inversely as the colloidal content. That is, the resistance to compression (discussed later under plastic soils) varied directly with the square of the colloidal content in soils when the colloid was sufficient to be the dominant factor. Up to this point the resistance to compression varies inversely as the colloid, and the percentage of compression is shown by Fig. 4 and the formula

$$F_c = -0.625\ C + 12 \qquad [10]$$

where F_c is the force of compression and C the colloidal content in per cent. It is evident from this that a small amount of colloid adhering to coarse soil particles either acts somewhat as a lubricant, by filling in the irregularities of the rough particles, or produces a structure less resistant to compaction.

Shear. Forces producing shear are not confined in their action to a single plane. The interlocking of particles and the cohesive action of moisture films cause the reaction to spread throughout a considerable mass of soil on each side of what is usually considered the shear plane. Under these conditions it is logical to expect a reaction

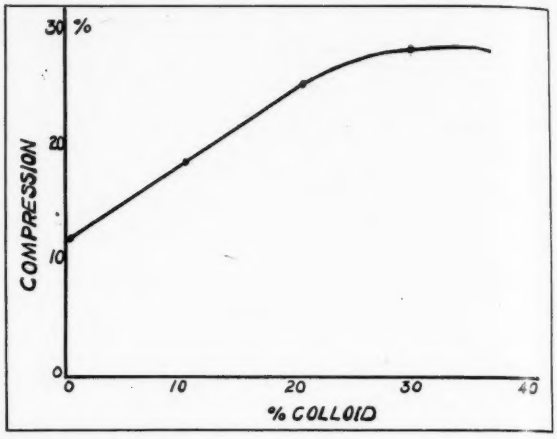


Fig. 4. The relation of the amount of compression of a non-plastic soil to colloid content

which would be a resultant of compression and cohesion values. Physical measurement of the values of a reaction of this kind are somewhat difficult to interpret because, when the soil is confined for the purpose of measuring shear, the resistance to shear itself causes a compression of soil. This in turn increases shear resistance, which is thus cumulative until a certain peak is reached at which point the soil suddenly gives away. Shear value was found to be directly proportional to pressure. The maximum value of this reaction for 15 pounds pressure, in this study, was called the shear value.

The shear values obtained with the synthetic soils increased up to the point where the soils became plastic. The variation to this point was proportional to the colloidal content. From this point the shear value increased with the colloidal content but not in simple proportion, which is in accordance with the compression reaction as previously shown. Since the shear of plastic soils will be discussed later, it is only necessary to show here the relation of shear values of non-plastic soils to colloidal content. The approximate shear value in pounds per square inch for non-plastic soils was found to be expressed by the equation

$$S = 0.013\ C + 0.5 \qquad [11]$$

where S is the maximum shear and C is per cent of colloid.

PLASTIC SOILS

Atterberg Plasticity Constants. Soils may be classified as plastic and non-plastic. This classification is arbitrary in that all soils possess, at least to some slight degree, evidences of plasticity. From the studies of compression, however, it has been shown that there is an actual change in the nature of the soil's reaction at a point where the colloidal content is sufficiently large to produce a well-defined plasticity. It is also quite evident that this change in reaction is due to film moisture. With a small amount of colloid the amount of water required to saturate the films would be small, and the moisture range over which indications of plasticity are evident would be correspondingly small. When very small amounts of colloid are present, these particles would be quickly and completely saturated, and the films surrounding aggregates would give practically the same effect as films on non-colloidal particles. With larger amounts of colloid the amount of moisture required to furnish films for these particles would be large, and the moisture range over which plasticity occurs would be correspondingly large. These facts agree with general observations and further support the colloidal film theory.

It has also been shown that the moisture content, at which the maximum reaction occurs, varies directly with the amount of colloidal material. It was found that the

amount of variation of these reactions was a function of the colloidal content and that the relationships could be expressed by straight line formulas up to the point where plasticity occurred. It therefore remained to establish the relationships between colloidal films and the reactive properties in plastic soils.

It is quite unnecessary to prove that plasticity is associated with, if not entirely due to, colloidal material in soils as this is already a generally accepted fact. The relationship between a soil's reaction and the Atterberg plasticity constants has been published[8,12]. A brief summary of the most important findings, however, is given as a basis for the discussion which follows. It was found that within the range of forces entering into tillage operations that

"1. Maximum adhesion occurred at a moisture content fairly close to the upper plastic limit.

2. The moisture range over which adhesion took place and the moisture content at which maximum adhesion occurred were functions of the plasticity number.

3. The range of maximum compressibility of a soil is approximately the same as the plasticity range on the moisture scale.

4. The maximum compressibility of a soil is a logarithmic function of the plasticity number.

5. The maximum resistance offered by a soil to the passage of chisels is a logarithmic function of the plasticity number.

6. A double logarithmic relationship exists between the plasticity number and that moisture content at which the resistance of a soil to a chisel or implement being forced through it begins to increase rapidly."

Since the above was published, shear has been studied, and it was found that the moisture content at which maximum shear occurs, as well as the amount of force involved, could be accurately determined by these constants. The details of these reactions will be dealt with in subsequent papers.

Lower Plastic Limit. With the relationship of the Atterberg consistency constants to the dynamic properties of plastic soils established, it remained to show the relationship of these constants to the film theory. It has been shown by Atterberg[7] that the amount of colloid determined the place of these constants on the moisture range. Later Baver[8] confirmed this finding and showed that the chemical composition governed the moisture percentage at which plastic limits occurred.

The ratio method of determining colloidal content consists of dividing the amount of moisture which a soil will absorb under controlled conditions by the amount of moisture that one gram of separated colloid of that soil will absorb under similar conditions. It is evident that this absorption of the colloid indicates the affinity of the colloid for moisture, and it is a measure of activity of the colloid as far as moisture is concerned. Since the variation of the Atterberg constants on the moisture scale is a variation of the moisture percentages at which activity is evident, this absorption was studied to see if it would explain the variation of these constants.

It was apparent that the chemically combined or absorbed moisture of the soil would not enter into film reactions. With different soils, therefore, the physical activity per unit of water would vary, depending upon the amount required to satisfy the surface demands of the individual colloidal particles and the amount of colloid present. The physical activity of the water would be inversely proportional to surface demands and directly proportional to the colloidal content or total effective surface for film action. The place of maximum activity (lower plastic limit), or percentage of water at which activity occurred, should then be proportional to the activity of the moisture. It is to be expected that the greater the activity of the water, the lower the lower plastic limit would occur on the moisture scale. A mathematical expression of this statement would be

$$P = \frac{KC}{M} + b$$

That this occurs is shown in Table III and Fig. 5. This data was taken from the work of Parker and Pate[13] and others. The results represent a very satisfactory agreement with the theory, although the method of determining the lower plastic limit used is rather crude. An approximate formula for relationship is

$$P_1 = 0.361 - \frac{C}{10M} \qquad [12]$$

where P_1 is the lower plastic limit, C the colloid content, and M the moisture absorbed per gram of colloid.

Table III. Lower Plastic Limits and Activity of Moisture of Various Soils

Soil number	Lower plastic limit	Colloid content (C)	Moisture absorbed by colloid (M)	C / M
548	23.8	37.0	21.0	1.76
203	23.8	55.0	32.5	1.77
3	21.3	29.5	21.6	1.36
316	21.2	34.6	21.6	1.58
314	20.8	31.3	23.0	1.36
2	20.5	28.9	16.9	1.71
6	18.3	36.0	21.2	1.70
317	18.1	25.0	19.5	1.28
7	18.0	37.0	21.5	1.72
8	17.8	43.8	21.4	2.04
9	15.4	28.6	17.0	1.68
315	13.0	32.0	12.5	2.56
10	14.4	30.3	12.4	2.44

Plasticity Number. If the physical reactions of soil are due to colloidal films, the lower plastic limit is close to that moisture content at which this film action first becomes evident, and the upper plastic limit is that moisture content at which these films are so expanded that their force is materially reduced. Since the variation in place of occurrance on the moisture range of the lower plastic limit has been shown to be due to absorbed moisture, which does not enter into film action, and since the upper plastic limit occurs at a point which is the arithmetical sum of the moisture content of the lower plastic limit and the plasticity number, it is only necessary to show that the plasticity number is a function of the amount of colloidal content to substantiate the theory for

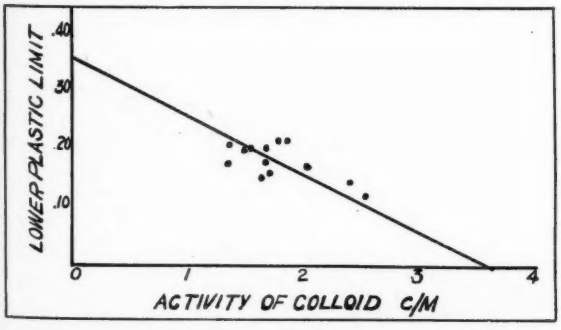


Fig. 5. The relation of the place where lower plastic limit occurs to the activity of the soils moisture

[12]Nichols, M. L. Dynamic Properties of Soil Affecting Implement Design. AGRICULTURAL ENGINEERING 11: 201-204, 1930.

[13]Parker, F. W. and Pate, W. W. Base Exchange in Soil Colloids and the Availability of Exchange Calcium in Different Soils. Jour. Am. Soc. of Agron. 18: 470-482, 1926.

plastic soils. Fig. 6 and Table IV show this relationship. An approximate equation expressing the relationship is

$$P_n = 0.000489\ C^{2.67}$$

where P_n is the plasticity number and C the colloidal content. The formula indicates that a soil with between 15 and 17 per cent colloid would have a plasticity number of 1, which would coincide both with this theory and practical observation.

Table IV. The Relation of Colloid to Plasticity Number

Soil number	Colloid content per cent	Plasticity number
203	55.0	20.30
548	37.0	8.20
315	32.0	4.00
317	25.0	2.67
Sand ⅓ Clay ⅔	20.1	2.00

Since percentage of colloid is a mass measurement and our film theory calls for a surface relationship, the relation between colloidal content and plasticity number should be a mass surface relationship if the theory be true. This would be expected to be an exponential relationship which was found. The significance of the exponent is not, however, entirely clear, but its close approximation to the value e may be significant. The increments of colloid being added have close to the limit of surface for a given mass, and, therefore, the rate of variation of the total surface per unit of colloid increase would be close to the limit. The exponent 2.67 is close to the value of e, and

$$e = \frac{L}{K \longrightarrow \infty} = (I + \frac{I}{K})^k = 2.7183\text{—}$$

The Atterberg consistency constants are moisture percentages at which certain arbitrary reactions occur; they indicate the place and amount of the reactions of plastic soils. These constants also indicate the limits of film activity and the range over which it extends. The variation in place of the lower plastic limit is thus shown to be due to the amount of colloid and to the amount of moisture necessary to satisfy its chemical and absorptive demands. The range of activity, or plasticity number, is also shown to be a function of the colloidal content. It thus appears that the reactions of plastic soils are probably due to the films on the colloidal particles and that in these soils these films are the dominant reactive agencies.

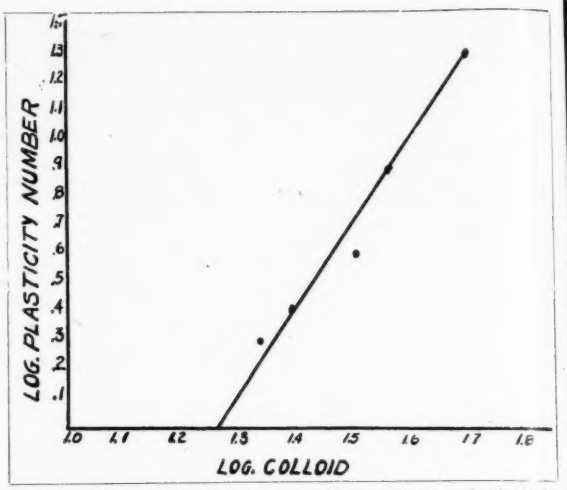


Fig. 6. The relation between colloidal content and plasticity member

SUMMARY

The reactive forces of all classes of soil are shown to be due to, or dominated by, the film moisture on the colloidal particles. The colloidal content can then be used as a means of calculating the place and amount of reactions of non-plastic soils.

The film force is indicated by the formula

$$F = \frac{K\,4\pi\,R\,T\,\mathrm{Cos}\,\alpha}{D}$$

where F is force, K a constant, R the radius of particles, T the surface tension, D per cent of moisture, and α the angle of moisture contact to the surface of the particle. The variation in place and amount of maximum reaction with non-plastic soils is shown to be proportional to colloidal content and is probably due to the action of film moisture on the colloidal particles.

The place and amount of the reactions of plastic soils are shown to be indicated by the Atterberg plasticity constants. The variation in place on the moisture range of these constants is shown to be due to the chemically combined and physically absorbed water which does not enter into film action. With the chemical and physical absorption accounted for, the plasticity number, which indicates the amount of the soil reaction, is shown to be a function of the colloidal content. These facts indicate that variation in the reactions of all soils is due to the film moisture on the colloidal particles.

Greater Geographic Specialization Probable[1]

THE economies in grain production which are being secured by mechanization will doubtless lead to a greater degree of geographic specialization and this tendency will be accentuated by the limitations set by topographical and climatic conditions. Complete advantage of the improved technique can only be taken in areas where the land is level. Rough, broken or stony land presents difficulties in the way of successful or economical operation of combines and lessens the relative advantage possessed by regions of this nature. For this reason we may expect to find the mechanized grain farm practically confined to the open prairies in Western Canada, and this in turn would concentrate livestock production in the parkland sections and in districts where hills, woods or sloughs form natural obstructions to combine operations.

The decline in land values which has occurred in recent years produces a condition favorable to the adoption of extensive methods. High land values stimulate methods which aim to produce a higher quantity per unit of land and this is secured by variable costs somewhat higher than would otherwise be profitable. Where the price of land is low, the inducement to intensive production is removed and factors which reduce the operating costs are acceptable. It is, consequently, probable that not only will the movement towards mechanization be stimulated by the existing depressed value of land, but the adoption of machine methods and the resulting phenomena will be most apparent in regions of low priced land. In addition, we would expect to find an extension of cultivation into marginal lands where topographical conditions favor machine production and particularly in regions of low rainfall.

Excessive humidity handicaps the combine by increasing the risk of loss and reduction of the grade of grain. Even in districts where the rainfall is not generally sufficient to prevent successful harvesting by the use of the windrower, the additional costs incurred lessen the advantage of the method and make competition with less humid parts more difficult.

[1]From "The Economy of Machine Production in Agriculture" by Andrew Stewart, published in "Essays on Canadian Economic Problems," Vol. IV.

Power Requirements of Spray Agitation

By K. R. Frost[1]

THE effective use of insecticides and fungicides requires that insoluble ingredients be uniformly dispersed in the water. Unsatisfactory control of pests and injury to trees have often resulted from imperfect spray mixtures. Oil sprays present a particularly difficult problem, owing to the fact that the oil tends to float out of the mixture and become concentrated at the surface. The floating out of the oil varies in degree with different types of emulsions. In the course of research during the past few years, R. H. Smith[2,3] has pointed out that the difficulties heretofore experienced as a result of imperfect spray mixtures can be entirely avoided by providing spray tanks with more effective agitation. Investigation has shown that it is practical to produce and maintain a uniform mixture of unemulsified oil and water in spray tanks and this fact, together with much supplementary evidence, has given rise to the tank-mixture method of using oil spray, which promises to come into extensive use, particularly in the spraying of citrus trees in California.

An important phase of the general problem of spray tank agitation, which heretofore has not been investigated, is the power required to operate agitation equipment. A survey of commercial sprayers in southern California has shown that in the case of many outfits the agitator speed is less than 120 rpm. Dr. Smith has recommended that the speed be increased to a minimum of 200 rpm. Sprayer manufacturers have raised the question as to whether or not the power required to drive the agitators at 200 rpm would be excessive. The present study was undertaken for the purpose of obtaining definite information on the subject.

The apparatus used in this experiment was regular orchard equipment of standard design. The spray tank of 300-gallon capacity had a cylindrical-shaped bottom with the agitator shaft running lengthwise. Three sets of agitator blades of different design were used to determine the relation of blade design to energy requirements (Figs. 2, 3 and 4). A speed reduction unit was necessary to transmit the power from the 1150-rpm motor to the agitator shaft. The frictional horsepower dissipated by this unit was determined by making test runs at different speeds with the tank empty and the blades removed. Water was used for all the tests as no difference in power consumption was noted when using the spray mixture or when the tank was filled with ordinary tap water.

A torque dynamometer was used to measure the horsepower energy consumed by the equipment and this was checked by making measurements of the electrical energy input. The results from the two methods checked very closely. Fig. 1 shows the arrangement of the testing apparatus including the sprayer tank, motor and speed-reduction unit.

Relation of Power to Speed. The three sets of agitator blades used in this test are shown in Figs. 2, 3 and 4, as they were placed on the shaft. The two end agitators were set to throw toward the center, and the two center ones to throw outward as recommended by Dr. Smith to give the best agitation. The set shown in Fig. 4 had the end blades placed as described above, but a single flat paddle was used in the center in place of the second pair.

Table I gives the results of the test and the blade specifications.

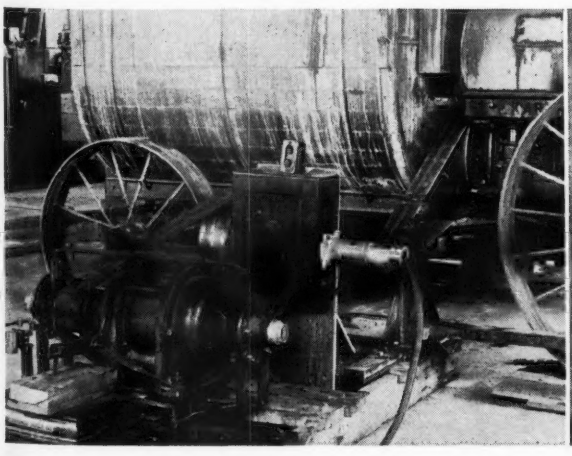
From a practical point of view it is necessary to consider the results in Column 5 rather than Column 7 in Table I, as a reduction unit is required to reduce the en-

Table I

Blade No.	Speed, rpm	Angle* of blade degrees	Blade surface sq. in.**	Total hp.	Frictional hp in reduction unit	Net hp consumed by blades
1	108	40	168.0	0.52	0.37	0.15
1	198	40	168.0	0.98	0.41	0.57
1	300	40	168.0	2.57	0.50	2.07
2	114	30	75.2	0.43	0.37	0.06
2	198	30	75.2	0.56	0.41	0.15
2	300	30	75.2	1.02	0.50	0.52
3	108	31	80.0	0.48	0.37	0.09
3	192	31	80.0	0.89	0.41	0.40
3	296	31	80.0	1.98	0.50	1.48

*Angle which inclination of blade makes with plane perpendicular to axis of shaft.
**Total area of set of blades measured on one side of the blade.

[1]Assistant in agricultural engineering, University of California. Junior Mem. A.S.A.E.
[2]Smith, R. H. Studies on spray tank agitation and the use of oil sprays. Jour. Econ. Ent. 22:929-934, 1929.
[3]A brief report on the tank-mixture method of using oil spray. Jour. Econ. Ent. 23:376-382, 1930.



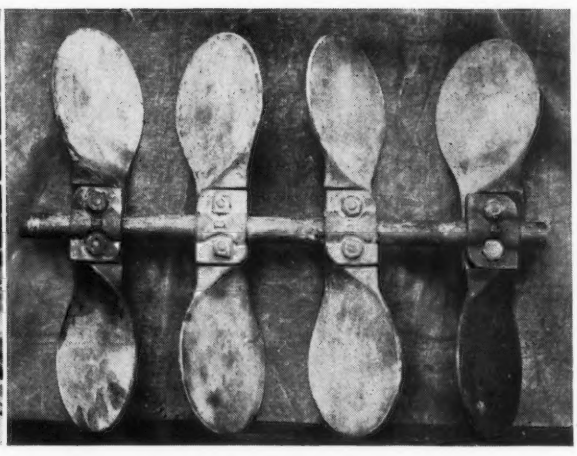


Fig. 1. (Left) Testing apparatus used to measure the horsepower consumed by the agitator blades. Fig. 2. (Right) No. 1 blades as they are placed on the shaft. Distance between blades varies from 10 to 14 inches depending on the size of the tank

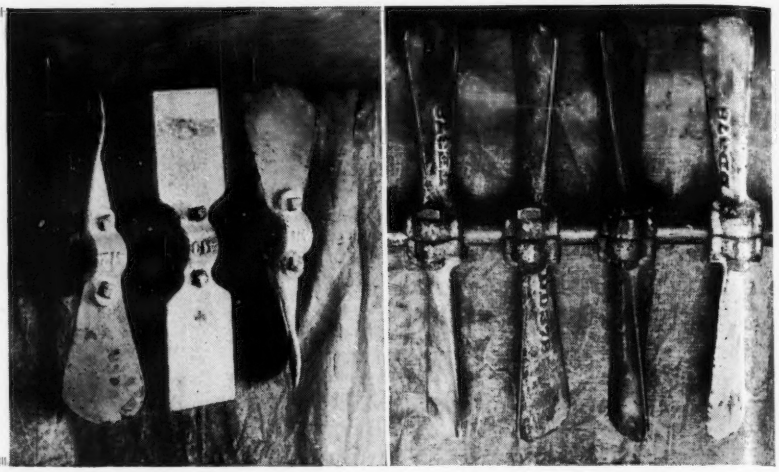


Fig. 3. (Right) Showing how No. 2 blades are placed on the agitator shaft and the angle of inclination. Fig. 4. (Extreme right) These No. 3 blades have a varying angle of inclination. The angle is 90 degrees at the shaft and 31 degrees at the tip

gine speed to the agitator shaft speed. The increase in power due to speed changes form 100 to 300 rpm are apparent from a study of either column. The curves shown in Fig. 5 are obtained by plotting the data in Column 2 as abscissae and the data in Column 7 as ordinates for points on the curves. The horsepower consumption can be determined from these curves for any speed ranging from 0 to 325 rpm for the three sets of blades. The curves show an increase in power approximately proportional to the cube of the speed for speeds in excess of 200 rpm. For speeds below 200 rpm the power varies between the square and the cube of the speed.

Relation of Power to Set of the Blades. The effect on the power consumption by changing the position of the blades is shown in Table II. In this test No. 1 blades were used, but instead of having the blades in a common plane the center blades were set in a plane at right angles to the end blades. In other respects the blades were in the same position on the shaft as for the previous test.

Table II

Speed rpm	Total hp	Frictional hp	Net hp
108	0.45	0.37	0.08
198	0.84	0.41	0.43
300	2.38	0.50	1.88

Comparing the data in Table II with the data for the No. 1 blades in Table I, it will be noted that the net power in the former shows a decrease of 0.07, 0.14 and 0.19 hp, respectively, for speeds of 100, 200 and 300 rpm. When the blades are not placed in a common plane as in the above test, the liquid is not agitated into a circular motion as was the case in the former test, but eddy currents are noticeable. The agitator blades when set in a common plane, tend to set the whole mass of water in motion thereby disturbing all the particles, even those most remote from the agitator.

Amount of Water as a Factor in Power Consumption. It is apparent that the amount of liquid in the tank has some relation to the power consumed by agitation, due to the fact that the volume of water set in motion is a measure of the work done by the blades.

Table III

Speed rpm	Gal. in tank	Frictional hp	Total hp	Net hp
307	100	.50	1.53	1.03
302	200	.50	2.48	1.98
302	300	.50	2.55	2.05

Table III shows the power consumption with the tank one-half, two-thirds and full when using No. 1 blades for agitation and operating at a speed of approximately 300 rpm.

In the first run (100 gal) air was incorporated with the liquid as the water level cleared the tips of the blades only about 2 inches, while in the 200 and 300-gallon tests the water was 12 and 21 inches, respectively, above the tips of the blades, thus permitting no visible air to come in contact with the blades.

CONCLUSIONS

1. The power requirement for agitation increases with the speed and is approximately proportional to the cube of the speed for speeds in excess of 200 rpm (Table I).

2. The power consumption is greatest for any given speed when the blades (vanes) are set in a common plane (Table II).

3. Other things being equal the power requirement is greatest when the blades are completely submerged (tank full), and the power decreases as the water level decreases (Table III).

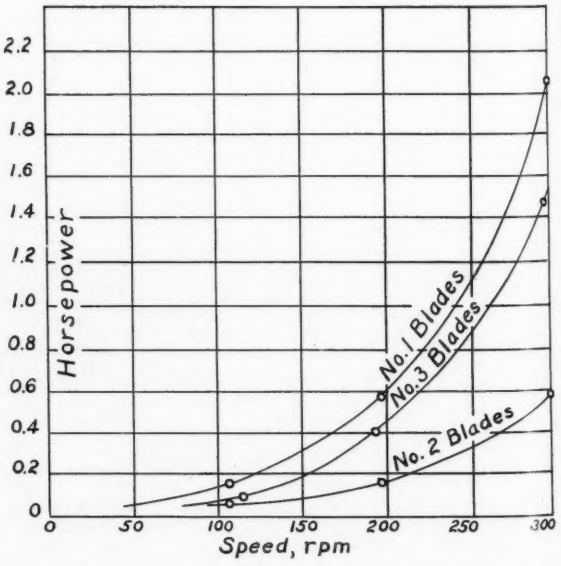


Fig. 5. Horsepower-speed curves of agitator blades in one plane, with 300-gallon tank (full)

Present Status of Mechanical Corn Picking[1]

By A. L. Young[2]

ALTHOUGH machines for picking corn have been on the market for twenty years or longer, it was not until within the past five years that farmers began to use them to any great extent. Today farmers in general are showing far more interest in the possibilities of the mechanical husking of corn than at any previous time. This rather sudden upward trend in the use of mechanical pickers appears to be due to various causes. The machines themselves have been greatly improved. Because of better design and the use of better materials, a modern two-row machine is lighter in weight than some of the former one-row machines. Although still more complicated than is desirable, the general layout of the more recent models is better; bearings, gears and sprockets are somewhat better protected from dirt, and facilities for proper lubrication are greatly improved.

The development and adoption of the power take-off drive has probably been the most important factor in making the corn picker more usable. It permits using the picker on soft ground where operation of a ground-driven machine would be impossible. It allows the rate of ground travel to be varied, by changing from one speed to another on the tractor, and yet keep the moving parts of the picker running at approximately the speed for which they were designed. Whereas in machines for the threshing of grain it is fairly important that the speed with which the various parts move be held nearly constant, this is not so important in the case of the picker, making it possible to operate the tractor engine at less than governor speed if necessary, because of temporary overloading or field and crop conditions. The power take-off drive has undoubtedly done much to make possible a reduction in weight of both tractor and picker and has reduced the total power required. Ability to operate the picker mechanism without moving ahead is helpful in case of clogging.

Another development, not entirely new, but likely to be given new impetus with increased use of general-purpose tractors, is that of mounting the picker on the tractor. Although one-row mounted pickers have been, and are still being operated very satisfactorily, the ability of the two-row mounted picker to go through a field at any point without disturbing unhusked corn is very much in its favor. Mounting the mechanism on the tractor tends to make the various parts rather inaccessible, and practically eliminates use of the tractor for other work during the corn-picking season.

Thinking farmers, interested in the possibilities of reducing cost of production by increased use of machinery, have in recent years begun to feel the need of corn-harvesting machinery. The crew that can grow the corn crop with modern machinery cannot easily harvest it by hand. Securing extra help for this is often undesirable if not impossible. The earlier ground-driven horse-operated machines could not be depended upon; the crew required to operate one of them could often get the corn in the crib more quickly when picking by hand and rarely stopping because of weather or field conditions, than they could with the machine. The development of tractor-operated machines that can be used in extremely wet fields, the better design and lighter weight of these machines, the bringing out of two-row machines, and the possibilities of tractor mounting, have all done much to increase the demand for huskers.

As regards the present status of mechanical corn picking, we can at least say that it seems to be rapidly changing. The machines are far from standardized, although the essential mechanism of the later models is much the same as that of the earlier machines. Changes are still being made in the shape, size, position and arrangement of gatherers, snapping rolls and husking rolls. Gears, sprockets and chains are being made of better materials, and in some cases given better protection. Gatherer chains and snapping rolls are being carried closer to the ground to permit better picking up of lodged corn. The top sheets of gatherers have been widened and made more rounding; sharp edges and corners likely to break stalks or in which ears can catch are being eliminated. Floating gatherer points get beneath and raise even very badly lodged stalks. Pieces of stalks pinched off by the snapping rolls are taken out at the upper end of the snapped ear elevators, any ears still attached being snapped off. Ear retarders and straighteners over the husking rolls increase their effectiveness. Safety slip clutches at various places protect against breakage in case of clogging. Simple hitches allow the wagon in which the corn is placed to be pulled by the tractor, and changing of wagons is done quickly and easily.

On the other hand, there are still, on most pickers, a large number of exposed gear and chain drives. Plain

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers, at Chicago, December, 1930.

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Mechanical husking of corn has greatly increased within the past five years, partly due to improvement in the machines themselves. However, there is room for considerable further improvement particularly in the reduction of corn losses

TABLE I. Corn Husking Losses in Champaign County (Illinois)

Year	Number of field	Average total yield, bushels per acre	Losses											Per cent of total loss already on the ground
			Shelled corn Bu. per acre			Ears Bu. per acre			Total Bu. per acre			Per cent		
			High	Low	Avg.	High	Low	Avg.	High	Low	Avg.	High	Low	Avg.
Machine-Picked Fields														
1929	9	57	5.4	0.6	2.0	7.9	0.8	3.7	13.3	1.4	5.7	24.8	2.0	10.2	
1930	18	47	2.2	0.4	1.2	22.3	1.4	4.7	23.0	2.1	5.9	39.1	6.4	12.5	36
Hand-Picked Fields														
1929	7	53							3.1	1.7	2.7	7.3	3.6	5.0	
1930	18	42							4.3	1.4	2.8	9.1	3.4	6.7	

bearings, not any too well supported, with the thrust of level gears taken only by washers, make it difficult to keep gears properly aligned and meshed, with the result that they often wear rapidly. Although fittings for pressure lubrication have done much to insure complete lubrication, the large number of places requiring greasing or oiling makes lubrication a laborious task and therefore one likely to be neglected. All too often the design of machines is such as to make it quite difficult to replace worn parts and make other repairs; the later models, however, show considerable improvement in this respect. Since the adjustment of snapping rolls greatly influences the loss of shelled corn, and often needs to be changed rather frequently to meet changing crop and weather conditions, it would seem that the machines should be so designed as to permit making this adjustment more easily and quickly.

In an effort to build light-weight, two-row machines, there is a tendency to considerably reduce the number and length of husking rolls in proportion to the amount of corn to be handled, and some farmers complain of the amount of husks left on the corn. When stalks and husks are damp and tough, the snapping rolls remove a large share of the husks, leaving comparatively few to be taken off by the husking rolls; when the corn gets dry, even the best of husking rolls are apt to leave more husks than the farmer likes to see. Several manufacturers have attempted to market machines equipped only with snapping rolls, but there seems to be a rather definite demand on the part of farmers for a machine that will do a better job of husking than can be done with snapping rolls alone.

It has often been suggested that the husking rolls should be placed at the crib and operated as a part of the elevating equipment. Such a scheme would simplify and greatly reduce the weight of the field picker. On the other hand, considerable power would be needed at the crib, for in addition to the husking rolls, there would need to be a container into which an entire load of corn could be dumped and provision made for feeding this to the husking rolls at the proper rate. Whereas now one man can often haul the husked corn from the field and elevate it into the crib, placing the husking rolls at the crib would usually necessitate having an additional man stationed there to operate them. However, the designer of these stationary husking rolls would not be limited by the necessity of keeping the weight low, as he now is, and they probably could be given sufficient capacity to do clean husking regardless of crop conditions. The field picker, being much lighter in weight, could be operated under very adverse field conditions, and it is quite possible that the extra work that could be done would more than justify the additional man labor and power.

I have said that corn pickers are not mechanically all that we would like to have them be. I have mentioned the difficulty of operating them in extremely wet fields, and of securing a reasonably clean job of husking when the corn is very dry. Perhaps more serious than any of these is the tendency to leave excessive amounts of corn in the field. During the fall of 1930 practically all users of machine pickers in east central Illinois have found it necessary to go over the fields and pick up ears left by the machine. This does not necessarily mean that the machines are doing poorer work than in former years, since tests made in fields where machines were operating have shown that, on an average, about 36 per cent of the total loss consisted of ears that had fallen from the stalks before the corn was picked. This, of course, is a very unusual condition and would indicate that some of the ears still on the stalks were not as firmly attached as in normal years, since there had been no bad storms to loosen the ears.

TABLE II. Apparent Influence of Certain Variables on Losses in the Mechanical Husking of Corn (Champaign County, Illinois, 1930)

Varying conditions	Number of field	Average Losses, Bu. per Acre		
		Shelled corn	Ears	Total
Stalks dry and comparatively brittle; corn well matured	14	1.0	3.3	4.3
Stalks damp and tough; corn well matured	4	1.6	1.4	3.0
Tractor operated in low speed	6	1.1	4.1	5.2
Tractor operated in intermediate or high speed	6	1.1	4.5	5.6
Lodged corn leaning mostly toward the machine (sidewise)	6	1.8	3.7	5.5
Lodged corn leaning mostly away from the machine (sidewise)	6	1.5	2.9	4.4
Lodged corn leaning mostly forward (with respect to travel of machine)	2	1.0	2.5	3.5
Lodged corn leaning mostly backward (with respect to travel of machine)	2	1.0	3.6	4.6
Experienced operator	3	1.6	0.7	2.3
Inexperienced operator	3	2.0	4.3	6.3

Note: These figures do not include ears that had fallen from the stalks before the corn was husked. Except in the case of the dry and damp corn, the contrasting conditions were obtained in the same field, with other conditions remaining approximately constant.

Table I shows the results of some loss tests made behind mechanical pickers and also in hand-picked fields by the farm mechanics department of the University of Illinois. In both years the number of fields in which tests were made was entirely too small to say that the average losses obtained are representative of the average losses for that part of the state. These tests do show the wide range of losses, and probably give a fair indication of the difference between losses in average machine-picked and hand-picked fields.

In Table II certain of the tests made in 1930 have been used in an attempt to show the influence on losses of certain operating and crop conditions. No effort has been made to show losses for different types or sizes of machines since no two machines were being operated in the same field. In calculating the losses as shown in this table, the loss due to ears that had fallen off previous to husking is not included.

In these loss tests the shelled corn and the corn from ears were weighed and calculated separately. In the tests made in 1929 at the Illinois station about 35 per cent of the total loss was shelled corn, whereas in 1930 the shelled corn constituted only about 20 per cent of the total loss. If, however, we do not include the ears already on the ground, the shelled corn becomes approximately 32 per cent of the total in 1930. In 1929 very few ears had fallen off the stalks previous to husking, and they were not collected separately as they were in 1930.

In practically all of the later models of pickers about the only place a loss of shelled corn can occur is at the snapping rolls, the amount of shelled corn passing out with the husks beneath the husking rolls being almost negligible. The loss at the snapping rolls appears to be influenced by (1) the distance between the snapping rolls, (2) the moisture content of stalk and shank, (3) the maturity and moisture content of the ear and the ease with which the corn can be shelled, (4) to some extent, probably, the shape and speed of the snapping rolls and the length of time the ears tend to remain in contact with them. Probably the most important of these is that of distance between the rolls, and when the loss of shelled corn is excessive, investigation will usually show that this distance is greater than it need be. On the other hand, setting these rolls too close together when stalks are dry and brittle will tend to considerably increase the loss of ears, as well as clog the elevators with pieces of stalk, some of which may be carried over into the wagon.

As an extreme case, in one field in 1930 the loss of shelled corn was varied from 1.2 to 7.2 bushels an acre simply by opening up the snapping rolls when the stalks were tough. In 1929 a farmer was found operating his two-row picker in the morning, while the corn was still damp and tough, with the snapping rolls set as had been necessary the previous afternoon when the corn was brittle, with the result that the loss of shelled corn was 2.5 bushels an acre as compared to 2.2 bushels an acre ear loss. The figures given in Table II would indicate that the average operator will get somewhat higher shelled corn

losses when the corn is tough. When the corn is badly lodged, or when inexperienced or careless operators fail to keep on the row properly, more corn is likely to be shelled because of the greater tendency of ears to make contact with the snapping rolls near the lower end where the opening is greatest.

Apparently a great many factors influence the number of ears lost. Among the more important might be listed (1) the condition of the corn as regards maturity, moisture content, degree of lodging, etc.; (2) how the machine is operated, including rate of travel, how well it is kept on the row (or rows), and the height of the gatherer points; (3) the design of the machine, including size and shape of the gatherers, number and position of the gatherer chains, distance from the ground of the lower end of the gatherer chains and snapping rolls.

Undoubtedly the corn picker does by far its best work, from the standpoint of both losses and clean husking, early in the season, when stalks are still tough and the corn is not readily shelled. Most machine owners try to start their pickers as soon as the corn can be stored with a reasonable degree of safety. A small amount of experimental work has been done in an effort to dry corn harvested early in the fall with a picker to a point that will permit safe storage, but doing this considerably increases the cost of harvesting. However, considering both the better work done by the picker, and the fact that weather is much more apt to be favorable early in the fall than later, it is quite possible that artificial drying might profitably be made a part of the corn harvesting process.

Unquestionably the loss of ears in mechanical husking is greatly influenced by the extent to which the corn is lodged. When the stalks are tough a well-designed machine carefully operated will husk badly lodged corn with a surprisingly small loss of ears. When this lodged corn becomes extremely dry and brittle, ear losses are apt to be high in spite of all precautions, and the wise farmer will usually not try to operate his picker under those conditions. If the corn is dry but stands fairly well, it is possible to pick with reasonably low losses, but care in operation becomes extremely important.

It so happened that in three of the fields in which loss tests were made in 1930 a somewhat less experienced operator substituted for the regular operator while part of the series of tests were being made. In Table II is shown the average of results of tests made with inexperienced operators as compared to results in the same number of tests under similar conditions with experienced operators. How well the operator keeps the machine on the row seems to be extremely important, particularly if the stalks are brittle. One reason why traveling more rapidly often tends to greatly increase losses is that, at the higher speeds, it is more difficult to keep on the row properly. Owners of two-row pickers should adjust their planters to space the rows the distance apart for which the picker is designed. Although owners of two-row pickers may argue that they can satisfactorily husk corn planted with a three-row planter, the author has seen too much of the ill effects of operating a picker on improperly or inaccurately spaced rows to believe that such a practice is advisable.

The figures given in Table II would indicate that the rate of travel does not greatly influence losses; however, there are times, particularly when the corn is dry and lodged considerably, that losses tend to increase rapidly with an increase in speed. In both 1929 and 1930 fields were found in which the loss of ears was approximately twice as much when the tractor was operated in intermediate or high, as when it was in low speed. When the stalks are tough the total losses sometimes tend to be slightly higher at the lower speeds, apparently because the snapping rolls tend to shell more corn. In badly lodged corn, it is imperative that the gatherer points be kept practically on the ground, and to do this safely, operation at fairly low speed is usually necessary.

No comparative tests were made of different machines under similar conditions; therefore, no conclusions can be drawn concerning how losses may be influenced by differences in design. However, comparison of the work of some of the earlier models of a certain make of picker with that of the later models has convinced the author that certain changes in the design of a machine may very considerably decrease the amount of corn left in the field by the average operator. Large, well-rounded top sheets on the gatherers, with no sharp edges or corners to catch ears, help a lot. Carrying the lower end of snapping rolls and gatherer chains near the ground will save many additional ears when corn is badly lodged. The shape of the snapping rolls is important, and apparently is becoming fairly well standardized.

It is quite possible that the optimum speed of snapping rolls and gatherer chains will vary for different field and operating conditions, but to provide for speed changes of these is probably not practical. It does seem that manufacturers might well change their machines to permit adjusting the distance between the snapping rolls more easily and quickly than is now possible. Placing the snapping rolls in such a position that snapped ears will very quickly pass from the rolls to the elevator is important; on the other hand, the position of the rolls must not be such as will increase the tendency to break stalks when they are brittle.

Although the husking portion of the machine has little if anything to do with corn losses, the length and number of husking rolls, how well the corn is distributed over them, and how well ear retarders and straighteners placed over the husking rolls do their work, all influence the extent to which the ears are cleanly husked.

As yet, no great amount of work has been done to determine the comparative costs of machine and hand husking. A few of the available figures are given in Table III. The figures for Illinois were computed from records kept by cooperating farmers during the harvesting season. Similar records (by a somewhat larger group) were kept in 1929, and although the results of the two years work have not been published, it is thought that the final figures

TABLE III. Cost of Husking and Cribbing Corn

Place	Years	Mechanical Husking								Hand Husking			
		One-row pickers				Two-row pickers							
		Number of farms	Average yield, bu. per acre	Cost per bu.	Cost per acre	Number of farms	Average yield, bu. per acre	Cost per bu.	Cost per acre	Number of acres	Avg. yield, bu. an acre	Cost per bu.	Cost per acre
East central Illinois*	1928	25	46.4	$.083	$3.84	34	49.2	$.066	$3.25	12,000	47.8	$.104	$4.96
Ohio**	1929	51	55.0	$.070	$3.85						53.9	$.120	$6.47
Iowa***	1928-9	1	35.0	$.062	$2.16	1	44.3	$.035	$1.55				

* Master's thesis of E. J. McConnell, department of farm organization and management, University of Illinois.
** Bimonthly Bulletin, No. 146, Ohio Agricultural Experiment Station.
*** From paper presented by E. M. Mervine at Moline meeting of A.S.A.E., June, 1930, before the 24th annual meeting of the American Society of Agricultural Engineers, June, 1930.

will not differ greatly from those given here. Apparently the Ohio figures were obtained by the survey method; more detailed figures can be obtained from the Ohio station. The figures reported by the Iowa station show strikingly how, in individual cases, the costs of mechanical husking may be kept extremely low. Since the acre cost of harvesting does not vary greatly with the yield, it is in the high-yielding fields that machine picking has the greater advantage on the basis of cost per bushel. The figures as given for Illinois include the cost of picking up corn left by the picker; whether or not this is true for the Ohio figures is not known. The Iowa figures do not include this item.

In conclusion, we may say that, although the mechanical husking of corn is definitely on the up-grade, the machinery provided for this work does not perform as satisfactorily as does most of the machinery used in growing the crop. More than one user of a corn picker has wished that his picker could be operated with as little mechanical trouble as can his combine. In spite of all the improvements that have been made in the machines, excessive amounts of corn are often being left in the field, and in the minds of non-users of the machines this is probably one of the most serious faults of mechanical husking. Although much can still be done to make the machines more reliable and durable, it would seem that particular attention should be given to the possibilities of reducing corn losses. The manufacturer can help considerably in the way he designs his machines. Possibly the plant breeders can give us varieties better suited to mechanical husking. And perhaps the farmers themselves can do more than any one else to reduce these losses by operating their machines properly, and when field and crop conditions are reasonably favorable.

Power Corn Planter Attachments[1]

POWER check-rowing attachments are new; every one of the reliable makes is especially designed for use with tractors, and in each one some accommodation has been made for increased wire travel. Furthermore, each make, like its horse-drawn predecessor, carries a checking adjustment by which the hills can be dropped closer to or farther from the check button in order to secure a perfect check whether a long, a short, a tight or a loose wire is used.

It probably will not be long before manufacturers perfect a mechanism by which the check wire will cross over the planter from one side to the other along a line approximately at right angles to the direction of planting. This is possible with the power planter because the tractor has at least three points of contact with the ground surface to absorb any sidedraft effects caused by torque action of the wire on the outfit.

Cross-over mechanisms will permit the check wire to assume a line parallel to the direction of planting. Hence, wire travel due to the wire swinging in an arc, and wire travel due to an angle at the headland, may be eliminated. But the old fundamental causes for wire travel due to the planter's pull on each button, and wire travel due to excessive speed probably will still be present with the cross-over arrangements.

The "kick-out" is the lower valve in each boot of the planter; it kicks the hill of corn out of the boot, and it is supposed to have such action that it materially offsets the tendency of the planter to carry the hill ahead due to the machine's motion forward. Not very long ago, horse planters carried "cut-out" check arms; that is, the check arm was straight on one side and cut out or offset on the other face. When you used a fast team you were supposed to have the straight side of the check-arm next to the button; then the hills were dropped a trifle sooner to offset the greater carry-over. Obviously, you reversed the check arm for use with a slow team. This was by no means a foolproof proposition.

Finally the kick-out valve was improved sufficiently to eliminate the necessity of the offset check arm, and for a number of years some makes of planters have carried only the straight arm. In other words, the kick-out and check adjustment could take care of any normal variations in speed possible with horses.

But the tractor planter may be run within a speed range of from 2 to 4 miles per hour. At 2 miles per hour we are dropping approximately 50 hills per minute if a three-foot-six wire is used; at 3 miles per hour, we are dropping about 75 hills per minute; and at the 4-mile speed, 100 hills per minute. Five hills in three seconds is surely planting corn. That would make the click of the average horse planter sound like a funeral dirge.

With such a range of speeds possible with power planters we are bound to have checking troubles unless the operators will plant at the speeds recommended by the respective manufacturers. As a rule, the faster the outfit is run, the more the carry-over; that is, the more the hill is pulled forward, or closer to the button. Too much emphasis cannot be placed upon advice to maintain the speed recommended by the manufacturer, and then to secure accuracy of check by the internal check adjustments within the planter. There is going to be a tendency among operators to run too fast. Their tractors have a comparatively light load, and some operators, not knowing of the consequencies, are going to "step on 'er."

Relating the experience of an Ohio farmer will serve to illustrate the influence of speed, although this story may have a bad moral. This farmer found that his check was badly off when he ran his four-row planter at the recommended speed of 3 miles per hour. He could get no help from the dealer, and for a day or two his advertising of power attachments was decidedly negative in character. Finally he discovered that he secured a good check if he ran the outfit much faster, so he finished his planting at this increased speed.

This Ohio farmer should have maintained the slower speed and set the planter to give the proper check. Then he would have avoided the excessive wear and tear that is almost sure to result when the speeds are carried well over the recommendations.

The old rule for horse planters holds equally well for power jobs, namely, each time an anchor stake is set pull the wire as nearly as possible to constant tautness. If the wire is quite short, say, 40 rods in length, you probably will get a better check by using a fairly loose wire with the power attachment unless the planter uses a crossover wire.

Test for accuracy of check in the center of the field, or at a distance from the headlands at least one-third the length of the rows. With power planters, as with horse jobs, a perfect check should exist through the center of the field, although the extreme ends of the rows may be very slightly off check.

If fertilizer attachments are being used in which the fertilizer valves are operated by the check wire, set the check shaft spring tight enough to pull all seed and fertilizer valves shut quickly. If the spring is too loose, sluggish valve action, stringing, and mixing of hills may result. The fertilizer valves being operated by the check wire, and the check shaft spring being set tighter, causes an extra pull on the wire when fertilizer is being deposited at the hills. Hence the wire tends to travel more, and the planter may have to be set to drop the hills a little earlier or a little farther from the buttons.

[1]From an article, entitled "Getting a Good Check with Power Corn Planter Attachments," by C. O. Reed, professor of agricultural engineering, Ohio State University, which was originally published in "The Farm Implement News" for April 2, 1931.

Some Observations on Hammer Type Feed Grinders

By William Vutz[1]

LITTLE information has been published thus far about the performance of large hammer type feed grinders, although data from studies and tests on small electric-driven hammer mills has appeared. As the principle of grinding and the arrangement of the different parts of the machine are exactly alike in both cases, the data given for the smaller mills can in many instances be applied to the larger ones. The writer's experience on several of the larger hammer mills give power consumption figures for grinding and elevating that check closely with those published in an article by F. W. Duffee, of the University of Wisconsin, in the May 1930 number of AGRICULTURAL ENGINEERING, with reference to the grinding of grains. The handling of roughage and ear corn can best be done with large hammer mills and sufficient power to carry the peak loads.

As to the variety of machines now built, there are two different trends generally followed. Both trends use the swinging as well as the rigid or semi-rigid types of hammers. One trend is to increase the cylinder diameter to try to make it possible to drive the mill with any farm tractor of standard belt speed, without the necessity of changing the tractor pulley. This usually results in a driven pulley on the hammer mill of 3½ to 5 inches diameter, which is not a practical size to use to transmit power by means of a large belt. The other is to use a cylinder of smaller diameter and attain the necessary speed by means of a speed jack. This speed jack is a means to a more positive action of the tractor and engine belt on driven pulleys because of a diameter that is practical. Whereever a mill has to be driven through a very small pulley, it is necessary to tighten the tractor belt to the utmost that shaft and bearings can stand. This excess stress shortens the life of the grinder. The small size of driven pulley shortens the life of the belt. In such cases the addition of a speed jack will not only mean a more positive drive, but also prolong the life of the machine and belts. Some of the direct-drive mills cannot be brought up to the right speed even with the smallest driven pulleys. In such cases it is necessary to exchange the standard tractor pulley for one of larger diameter which not only means an extra expense, but is also undesirable in view of the other belt jobs that a tractor has to perform. Speed-jack pulleys can most readily be chosen to suit the engine speed and are generally furnished in the desired size without any extra cost.

[1]Engineer, J. I. Case Company. Mem. A.S.A.E.

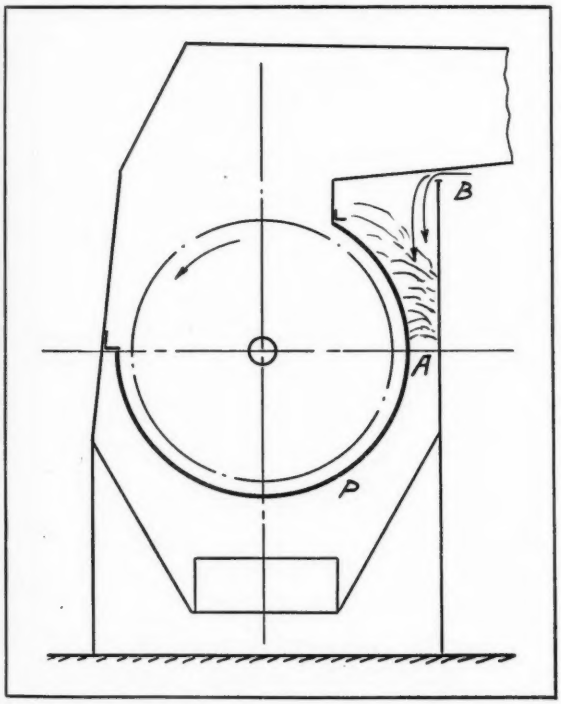


Fig. 1. When grinding on days when there is a high relative humidity, and using a very fine screen, this design will invariably be a failure due to bridging of the material at A, if this passage is less than 2 inches. An additional air intake at B might overcome this trouble. Also more or less leakage is bound to occur at the dividing line of the two screen halves at P unless great care is exercised in manufacturing machine and screens

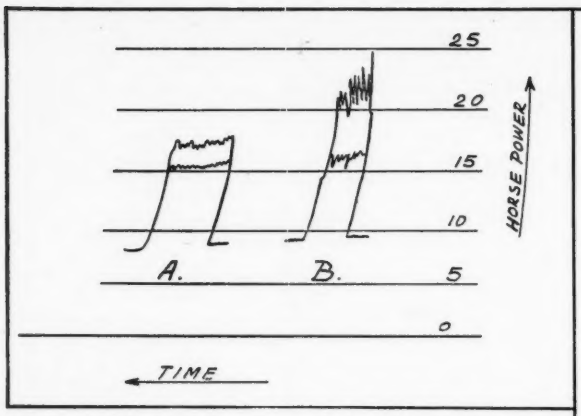
Capacity. The limiting factor as to capacity for a given horsepower is in most cases the size of the screen.

The peripheral velocity of the cylinder cannot be taken as a measure of the capacity, as a comparison of a few mills of different makes will instantly show. Although grinding is possible with a speed of 9000 feet per minute, and some manufacturers recommend velocities as low as 9500 fpm, it seems that in the lower range of grinding speeds the machines get much more sensitive against overfeeding and slugging of the cylinders. Most machines operate at velocities of from 12,000 to 15,000 fpm. The extremes vary between 9,400 and 18,800 fpm, according to manufacturers' ratings. The capacities claimed for the higher velocities are generally a little higher than for the lower ones. But this advantage is offset by the greater power requirements of the machines when running empty or alone.

The relative unimportance of the number of hammers that are at work in the process of grinding is shown by the following figures: Two mills (in this case operated by a 5-hp electric motor), grinding oats at the rate of 185 pounds per horsepower-hour, and one running at the peripheral speed of 13,000 and the other at 13,150 fpm showed this difference: In the first mill 90 hammers ½ inch wide turned over per second for each horsepower, as against 210 hammers 1 inch wide at the tip for the second mill. The extremes for this figure on present-day mills vary as much as from 27 hammers ½ inch wide to 200 hammers ¼ inch wide and 470 hammers ⅛ inch wide, but for the majority of machines it lies in between 60 and 120.

Some light might be thrown on this subject by a comparison of two mills of the same make. Both mills are of the same width, cylinder diameter, feed opening, speed, size of hammer, and screen surface, but on one mill the number of hammers is twice the number on the other one. The mill with the double number of hammers is rated at almost twice the power of the mill with less hammers. The manufacturers' ratings for small grain vary at the same rate as the power, but for roughage grinding the power increases faster than the capacity.

Regarding the shape of the hammers, it appears to the writer that in a percussion type grinder, all shapes and cutting edges, as far as they do not affect the width of the hammer tip, can be considered superfluous, since all the grinding is done by impact and all the claims for specially shaped hammer heads can only be considered as



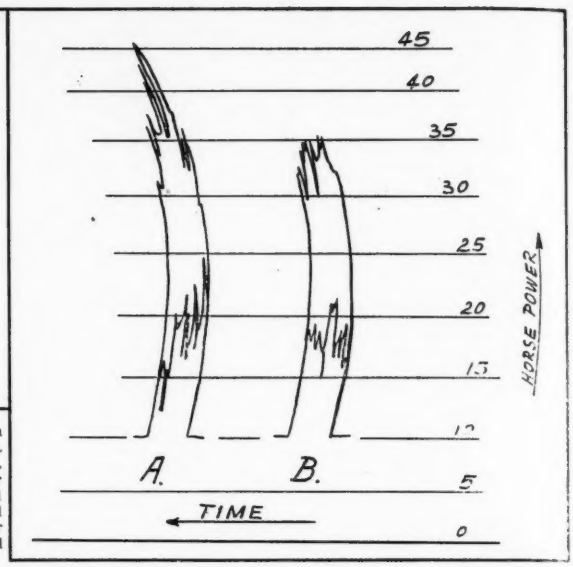


Fig. 2. (Above) Grinding power chart for grain and ear corn fed through a roughage feeder. (A) Grinding oats through a ¼-inch screen. (B) Grinding ear corn through ¼-inch screen. The zig-zag lines give the upper and lower limits of the power used. Fig. 3. (Right) Grinding power chart for alfalfa fed through a roughage feeder. (A) Machine governed by speed governor only. (B) Same machine governed by volume governor and speed governor. The zig-zag lines indicate the upper and lower limits of the power used

leading away from the actual principle involved in this type of machine.

The hammers will do good work as long as the working face is square and the corners are sharp. This makes it imperative that the hammers or tips be hardened. Hardened-steel hammers or tips give excellent results. On soft-center steel tips, the hammer face wears slightly concave after some use.

There is much difference of opinion in regard to the merits of the different types of hammers. The swinging type is supposed to be flexible, as a safeguard if anything too hard to be ground should enter the machine; although there is, however, some question as to what really happens. The centrifugal force of a hammer of 1 pound weight is around 1350 pounds at 29 inches cylinder diameter and 2000 rpm, so that the flexibility is therefore questionable. These hammers are easily replaced if worn and dull. There is also some wear at the point of hinging on both hinge and pin.

A rigid hammer assembly can be made stronger and safer since there are no loose or hinged pieces. The hammers are reversible when it is found necessary to turn them. The semi-rigid type is similar to the rigid type, but allows the hammers to give a little if anything hard, such as a piece of steel or iron, should be hit.

A 12-inch heavy file was accidentally fed into a machine of this type; it took about one-half minute before the machine could be brought to a standstill, yet there was no damage done to the machine. Three hammers had moved backward 1½ to 2 inches. After the remains of the file had been cleaned out, the machine was run again without relocating the hammers since each one is separately balanced. Their position relative to each other is unimportant.

The capacity for a given fineness and horsepower is limited by the size of the screen. At higher speeds the grinding is a little finer, and whenever there is enough power it seems good practice to choose the higher speed and a screen with a little larger holes to obtain a given fineness. However, there is a limit for each material beyond which the efficiency of a machine decreases with increased speed. Table I gives the net capacity figures for different materials at different speeds. From this it seems that, for the grains and ear corn on this particular mill 18 inches diameter and straight semi-rigid hammers, a speed of 3200 rpm is already beyond efficient limits. The most efficient speed for this machine is between 2800 and 2900 rpm. To be precise, it is somewhat below 2800 rpm for grains and somewhat above 2900 rpm for alfalfa.

Most machines have the lower half of the cylinder enclosed by the screen usually of one piece. In some makes an effort is made to gain screen surface by running the screen part way up into the upper grinding chamber. The idea of enlarging the screen area and thereby reducing the power necessary seems perfectly sound, but in most cases it requires two pieces of screen which in order to avoid leaks in the mill, call for closer limit on screens and housings. Failure of this design always occurs on the narrow passage between housing and screen on the horizontal center line of the cylinder, as shown in Fig. 1.

When grinding through a very fine screen, especially on days of high humidity of the air, this passage will be found to be blocked after a very short run and the upper part of the screen is then useless. For the same reason, care must also be exercised in the design of the feed hopper below the screen. Hopper sides at an angle of 60 degrees to the horizontal will work satisfactorily if the sliding surface is smooth and without protruding parts such as bolts or nuts.

Fan. The power necessary to operate a fan idle is in some cases greater than that necessary to run the machine itself idle. Sometimes power can be saved where only fine grinding is done by substituting a smaller fan for the original bigger one on a machine. The following is one case: One hammer mill that is well suited for grain and roughage was equipped with a 25-inch diameter by 6-inch fan. It will at 3000 rpm give 1¼ to 1½ inches of mercury, or 10 to 12 ounces per square inch of pressure, and can easily take care of even the greatest amount of roughage grinding for a distance of 80 feet. The idle power for this fan at 3000 rpm will be approximately 6 to 8 hp.

Now this mill in many cases will be chiefly used to grind grains or roughage quite finely. In those cases it is seldom necessary to elevate farther than 20 feet, and a 14-inch diameter by 5-inch fan was found to be large enough and actually did not take more than 2 hp to run idle. This was one-third the horsepower required to run the original fan.

Where the power is limited, a chain elevator instead of a fan is sometimes used. This method is a dusty and dirty job for the operator. The output per horsepower will be approximately the same for the same mill with either blower or chain elevator; the fan requires a trifle additional power, but at the same time aids in drawing the ground material through the screen. Replacing a blower by an elevator will only make a machine suitable for a smaller source of power and has no other advantage.

Table I. Grinding Done per Horsepower-Hour Through ¼-inch Screen at Different Speeds

	Speed, rpm 3200	2750	2450
	Pounds	Pounds	Pounds
Oats	234	261	
Barley	300	395	356
Ear corn	106	157	
Alfalfa	228	176	116

NOTE: This is the net grinding horsepower, that is, the total power used minus the power necessary to run the machine idle at each respective speed.

Feeder. Grains can be fed into the mill nicely by means of a simple hopper with an adjustable opening, provided the opening be not in the form of a long slot which often tends to an irregular stream of grain, due to straw and other impurities, but more nearly of square shape.

The handling of roughage can be done more pleasantly and more effectively by the use of a traveling feed table, especially in connection with some governing device. Whereas with a plain feed hopper 2000 pounds of loose alfalfa is good work for one man to feed in one hour, this figure can easily be doubled with a well-governed traveling feed table with a reliable volume or speed governor.

Automatic feeders of a threshing machine type, with a rake or an endless canvas or rubber belt, sometimes only an upper and lower roller with a toothed surface to give the necessary gripping action to take the material in toward the cylinder, serve a useful purpose. Unless they run at very low speeds, some kind of governing device is absolutely necessary. Most commonly a flyball type of speed governor is used.

These governors, if well and accurately made, will work very closely and are reliable. Some manufacturers furnish different sets of gears or sprockets for the feeder drive, because for fine grinding the governor would constantly be acting if the feeder were running at the same speed as in grinding coarse. Not only will constant governing action wear out disks or friction plates, but a certain loss of power and time must necessarily occur with each action, as the speed has to drop below a given limit before any action occurs.

The feeding of grain through these automatic roughage feeders is possible if provided with a grain tight bottom and a damper that checks the flow of grain so as not to have the governor work continuously. Ear corn can well be fed this way also; on feeders of higher speeds care should be taken not to place too much on the table at one time, as this again would keep the governor working continuously. Fig. 2 gives a grinding power diagram for oats and ear corn fed through a roughage feeder. Both runs can be considered as very smooth, as the power peaks or drops for oats were only 1 hp above or below the average, and for ear corn 3 hp above and 1 hp below. In this particular case the governor was set so that it acted when the speed of grinding hammers dropped 75 rpm below the normal speed.

On roughage the pressure applied to the material when it enters the grinding chamber has some influence on the capacity, especially grinding hay and straw. Tests indicate that the capacity rises slightly if the pressure between the upper and lower feed roller is increased. On machines that have a means of adjusting this pressure, it is generally good practice to use all the pressure on the feed roller that is still consistent with uniform feeding.

Any governing with a flyball type of governor takes place only after too much has been fed into the machine and the speed drops, which is undesirable; also most of the grinding is done in the range just above the acting speed of the governor. This led to placing a volume governing device in the feeder that regulates the amount of material fed into the machine before it ever reaches the cylinder, rather than interrupt the feed entirely after too much has reached the cylinder with its consequent slugging and recovering.

Table II. Comparison of Grinding Alfalfa With or Without Volume Governor

Speed rpm	Pounds per hour	Average horse power	Pounds per horse-power hour	
3200	3450	25.7	134	(Speed and volume governor)
3200	3090	28.9	107	(Speed governor only)

It is essentially the same type of volume governor as used on some of the most successful threshing machines. Contrary to the speed governor, it requires different settings for the various kinds and grades of roughage and screens and also the available power. This is done by a thumb screw adjustment while the machine is running under load.

Table II gives a comparison of two tests, one with volume governor and speed governor and the other with speed governor only. The tests were run successively on the same material with the same screen and the same man feeding. The output per horsepower-hour was 134 pounds with volume and speed governor and 107 pounds with speed governor only. Fig. 3 gives the power diagrams for those two tests.

Some idea about how closely a volume governor can be set might be gained from the following comparison: On one test, alfalfa was ground through a ¼-inch screen at a rate of 1210 pounds per hour, and the volume governor duly set for this run. The screen was then replaced by one with 1¼-inch holes, but the volume governor setting remained the same as before. The effect was that the net grinding figure per horsepower-hour jumped from 175 pounds for the ¼-inch screen to 420 pounds for the 1¼-inch screen, and yet it was not possible to feed faster than at the rate of 1500 pounds per hour, in spite of the fact that the net grinding power dropped from 6.9 hp for the ¼-inch screen to 3.6 hp for the 1¼-inch screen. It shows that a volume-governed feeder can be set so that a certain amount is continually fed. The advantage of a volume governor is particularly evident in cases where the power is limited and the engine would be pulled down by an overload. It also feeds in a more even stream than can be done with a speed-governed feeder alone, and, consequently, saves that amount of power that is otherwise lost in constant drop in speed and recovery of the cylinder while the speed governor is acting.

When setting the speed of a mill and the governing range, it should be borne in mind that a potential amount of power can be stored in a cylinder at this speed. That is to say, a reasonable drop in speed should be allowed before any action on the governor can occur.

The energy stored in the cylinder, when a drop of 200 rpm occurs, is quite enough to take care of overloads, as they continuously occur even with the best governed or fed machines, especially when grinding roughage.

If we take for instance a mill with 16 hammers 5 inches long, weighing 1 pound each, and with a cylinder diameter of 29 inches, running at 2000 rpm, a drop in speed of 200 rpm or 10 per cent will release about 2000 foot-pounds from the hammers alone, not including the disks, pins, etc. This actually does not save any power, for the cylinder has to be brought up to speed again, but it eliminates to a great extent load peaks and provides a smoother run for the engine.

Need of Standard Ratings. There is at this time a decided need for some standardization of capacity figures in hammer mill ratings. It is impossible for the average purchaser to get a clear picture of what he might expect in his particular case. Some manufacturers give approximate minimum and maximum figures without any reference to screen and power used. Some are very conservative as to their claims, and their ratings can in many cases easily be exceeded; others approach more closely the upper range and are on dangerous ground.

Within the capacity range of any particular mill and a

certain screen, the net grinding power requirement does not vary appreciably with the amount fed of a given material, but it varies with the speed, because the grinding is done by impact and the amount of energy given off by a blow is directly proportionate to the weight of bodies involved and changes quadratically with the velocity. The net grinding power is the power used to do the grinding only, i.e., the total power minus the idle power requirements of mill, fan, etc. The gross capacity includes the power of the grinder also. This should give a means of clearly defining the capacities and advantages of a machine for the purpose that it was designed, and also enable a prospective buyer to determine approximately the size of the mill for his needs.

At present good practice would be to rate a hammer mill in gross pounds per horsepower-hour through ¼-inch screen. This figure will be liberal to suit the great variations in grade of material but still be closer and more precise than many of the current ratings. On this subject of rating it might be desirable to correlate the figures made by various agencies toward an end that will end our present chaotic method of rating these grinding machines.

This rating should include a note to base capacities on the lower figures if the power at hand is on the lower limits of the recommendation. Similar practice is followed by some manufacturers already.

Considering the importance of holding the correct grinding speed, it is good to print or stencil the correct speed **under load** clearly visible on every machine. This applies especially to machines that do not have a speed governor, but to some extent to speed-governed machines also.

The Design of Grain Storage Structures

By J. D. Long[1]

WITH the growth of large-scale farming and the demand for farm storage, the design of grain storage structures is of increasing interest to agricultural engineers. Large storage and processing units become the agricultural engineer's responsibility.

This paper is concerned with structural safety, primarily as regards two of the newer structural materials. Design of the layout and selection of equipment to effect economy of storage and handling are, of course, also items of major importance in any elevator plan.

Structural Design. The characteristics of stored grain have occupied the interests of various investigators during the past fifty years. The results of their findings may be briefly summarized as follows[2]:

The lateral pressure of the grain, tending to burst the bin walls, is one of the first structural phases to be considered. It does not follow the law of the pressure of fluids, but varies wth different grains from 0.3 to 0.6 of the vertical pressure and increases very little after reaching a depth of 2½ to 3 times the width or diameter of the bin. The ratio of lateral to vertical pressures is not a constant, but varies with different grains and bin wall materials.

Janssen's solution is most widely used in determining theso quantities. His formula is:

$$L = \frac{wR}{\mu}\left[1 - e^{\frac{-k\mu h}{R}}\right]$$

where L = lateral pressure of the grain in pounds per square foot
V = vertical pressure of the grain in pounds per square foot
w = weight of grain in pounds per cubic foot
$R = A/U$ = hydraulic radius of bin in feet
A = area of bin in square feet
U = circumference of bin in feet
μ = coefficient of friction of grain on the bin walls
e = base of the Naperian system of logarithms
$k = L/V$ = ratio of lateral to vertical pressure
h = depth of grain at any point.

Both μ and k can only be determined by experiment on the particular grain and kind of bin. A summary of values determined by various investigators is given in Table I. Most of the work, naturally, has used wheat for the grain. Relatively wide variations are found in the values determined by different tests, due largely to the condition of the grains used and the character of the structural materials.

For practical design purposes the following coefficient values are frequently assumed: $\mu = 0.417$; $k = 0.6$, and $w = 50$. Such assumptions are safe for wheat which constitutes the heaviest loading commonly encountered other than flaxseed, which it will be seen in the table has a lower volume-weight but a higher coefficient of friction. Due to the very evident lack of definite and consistent data and the dependence on precedent, it will be readily appreciated that a competent consultant should be secured by a novice designer on important work.

A number of interesting factors are to be considered. Due to the characteristics of the materials, wooden bins are more economical in square or rectangular cross-section, steel and concrete bins in round sections. Moving grain causes slightly higher pressures than stationary grain, estimated as 10 per cent greater as a maximum. Due to some settling action of the grain, the lateral pressures decrease slightly when allowed to stand after filling. Sudden stoppage after withdrawal has no appreciable effect on the pressures. Tie rods have little, if any, effect upon the lateral pressures, but do decrease the rate of flow from the discharge gates. Eccentrically placed discharge gates lessen the lateral pressure on the side near the discharge and increase it on the side opposite. This difference from static pressure is considerable in some instances, according to some estimates two to four times normal on the side opposite, but has not been commonly considered in commercial elevator design.

In farm elevator design these conditions are aggravated in many instances by placing an outlet gate some 7 feet high on the bin wall to discharge by gravity into a truck, only that grain in the lower portion of the bin having to be put through the bottom outlet into the elevator leg when shipping out. No experimental data are available on this design.

The design of circular bins to withstand lateral pressures is relatively simple; square and rectangular bins present more difficulty due to the varying efficiency of corner ties.

The load on the bottom of the bin is readily determined by the relationship, $V = k\,L$.

An appreciable amount of the weight of the contents of the bin is carried on the bin walls. In deep bins it is by far the greater amount of the load.

For bins with a depth greater than two diameters the total load carried by the bin side walls is given by the total pressure per lineal foot, P, of the grain on the bin walls, multiplied by the perimeter and the coefficient of friction.

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[1]Junior agricultural engineer, University of California. Assoc. Mem. A.S.A.E.

[2]Ketchum, "Walls, Bins and Grain Elevators." Third Edition (1925), p. 351.

$$P\,U\,\mu = y\,R\,(h - \frac{R}{k}) \text{ Approximate}$$

$$= w\,A\,h - A\,V$$

Grain bins designed by the fluid theory are in many cases unsafe, as no provision is made for the side walls to carry the weight of the grain. Examples of this type of failure are cited later in this paper.

If the ground support can consist of a mat, foundation difficulties are minimized and the design simplified, since the mat must only support the small bottom pressure of the bin, resist the shearing stress of the side walls and provide bearing area sufficient to transmit the total load to the soil.

Since most designs call for a pit for the elevator boot, and many designs for a conveyor tunnel beneath a double row of bins, foundation design is more complicated. The difference in soil reaction beneath a deep pit or tunnel and at the surface of the ground under a slab footing, may be so different as to set up severe strains at the juncture of the pit walls and the surface mat.

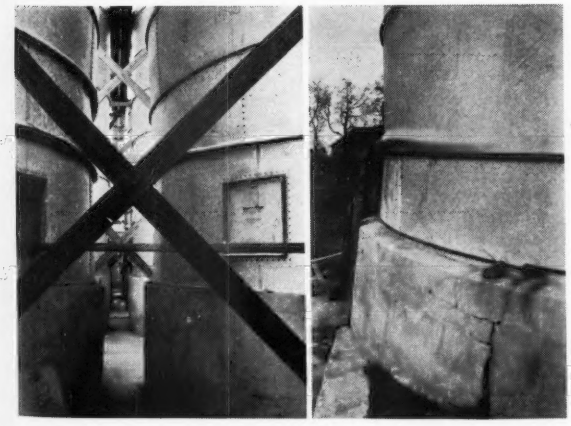
Due to the relative height and small base area, an elevator design should also be checked for resistance to overturning by wind and earthquake.

Sheet Metal Bins. In many areas sheet metal bins are popular for farm grain storage. In small sizes, such as are used for movable field bins, these have proved safe except as they may be damaged by wind when empty because of ineffective interior bracing or insecure ground ties.

In the West, in California particularly, this construction material has proved very popular for the larger farm and commercial elevators. Some structural failures have occurred in these larger bins due to the weakness of the side wall in vertical compression when not supported by the lateral pressure of the grain.

In the one outstanding instance noted the bins of an elevator on a large corporation farm failed by wrinkling horizontally on the discharge outlet side as the gate was opened. The bin was 22 feet in diameter by 21 feet 6 inches high, and composed of seven rings of galvanized sheets varying from 16 to 20 gauge, placed on a 6-inch concrete wall 4 feet high. The discharge opened through the concrete bottom of the bin approximately 2 feet from the wall. When the gate was opened, according to the experimental evidence, the lateral pressure immediately above the gate was materially reduced, and the unsupported sheets were unable to carry the vertical load imposed by the grain above.

This construction has now been strengthened by the addition of ¼ x3x3-inch angles placed vertically on two-foot centers around half the perimeter of the bin, symmetrical with the outlet, and seated on the concrete footing wall. According to Ketchum (page 359) there is no rational method for the design of these stiffeners.



(Left) Failure of sheet steel bins of a grain elevator on a corporation farm in California due to an eccentrically placed discharge and lack of side wall stiffeners. (Right) The fill behind a concrete retaining wall settled, cracking the concrete bin footing, which was supported partially on the retaining wall, and inducing a partial failure in the sheet metal bin

Table I. Coefficient Values

	Weight lb. per cu. ft.	Rough boards (wood crib)		Smooth boards (balloon frame)		Steel, (plate and galvanized sheets)		Cement concrete (monolithic)	
		μ	k	μ	k	μ	k	μ	k
		0.420		0.300	0.38	0.365		0.400	
Wheat	49	0.450	0.45	0.400		0.468		0.425	0.6
Barley	39	0.424		0.325		0.376		0.452	
Oats	28	0.450		0.369		0.412		0.466	
Shelled corn	45	0.344		0.308		0.374		0.423	
Beans	48	0.435		0.322		0.366		0.442	
Peas	48	0.287		0.268		0.263		0.296	
Flaxseed	45	0.407		0.308	0.50	0.339		0.414	
Rye	45	0.540	0.30	0.460	0.30			0.850	0.3
Tares	49	0.424		0.359		0.364		0.394	

Concrete Stave Bins. So far as is known to the author no experimental work has been done on concrete staves directed definitely toward their use in grain bins. The construction has been adapted, however, from silo practice and is enjoying a just popularity.

According to the standard specifications and building regulations for concrete staves of the American Concrete Institute[3],

1. The load on any concrete stave wall, including the superimposed weight of the wall, shall not exceed 200 pounds per square inch.
2. The steel reinforcing hoops placed around the outside shall be spaced at such intervals that the staves will not be loaded to exceed 25 per cent of their average transverse strength. The ultimate transverse strength of the staves at 28 days is required to average 90 pounds, with no test falling below 75 pounds, for each inch of width of the stave, when tested on 24-inch bearing centers
3. The absorption at 28 days must not exceed 6 per cent.

From the tests made by the Institute committee formulating these standards, it is apparent the specifications demand a high-quality product, probably not reached by many of the small manufacturers in the field.

Estimating the grain pressures in stave bins until such time as fundamental data are available, will be a matter of judgment on the part of the designer. Due to the numerous horizontal joints between staves, and the small interior ledge on each, the vertical loading carried by the wall may be more than on a monolithic wall.

If a truck discharge opening is incorporated into the wall, it would seem advisable to design for four times normal lateral load to a height 15 feet above the opening. The wall should be checked in column action, particularly in the case of an eccentric discharge. Good construction demands cement mortar in the joints, not only for water tightness, but also to prevent crushing of the end of an uneven stave to secure even bearing.

In designing the steel reinforcing rods it has been suggested that 10 per cent should be added to the area to balance the bond action secured in monolithic walls. A flat strap rod is probably preferable to a round rod, even though more surface area is exposed to the elements because of the tendency of the latter to crush into the concrete to a full bearing.

[3]Proceedings of the American Concrete Institute, Serial Designation P-4, A-26, Volume XXII.

Comparative Effectiveness of Hand and Mechanical Corn Picking[1]

By W. H. Carter[2]

NOTWITHSTANDING the difficulties the corn producer encounters in raising his crop, he is further confronted with the problem of harvesting it with as little loss as possible. Although the mechanical picker has increased the capacity of the individual worker and reduced the drudgery connected with the operation, there seems to be considerable evidence that its degree of effectiveness is yet somewhat unsatisfactory. In determining the method of harvesting corn the producer finds himself balancing the advantages and disadvantages of mechanical picking against those of hand picking, or vice versa, considering, of course, all the influencing factors, such as yield, size of ears, condition of corn, wages, weather, etc.

For three years students enrolled in farm machinery courses at Iowa State College during the fall quarter have devoted a portion of their laboratory time to studying and checking the effectiveness of mechanical and hand picking. During this time over 39 tests were made and the results assembled. While it is possible that these trials are too few in number and do not cover enough situations to give a complete picture of the corn picker-husker's comparative effectiveness, it is believed that the results are fairly representative.

The main object of the checks on both hand and mechanical picking was to determine the amount of corn left in the field. Of the several checks on hand picking, it was found that the percentage left in the field varied from 0.25 to 14.3, with an average of about 3.6. This average is above that of contestants in corn picking contests. Table I gives a summarization of results of three (hand) picking contests.

Mechanical picking was checked to determine the amount of corn left in the form of ears and kernels. The total percentage varied from 0.5 to 20.5, striking an average of about 8.1. When this average is compared with that of hand picking, it is evident that there is need for improvement. In studying these data one might conclude that the amount generally left in the field by the mechanical picker under average conditions is about the same as that left by the poorer hand picker.

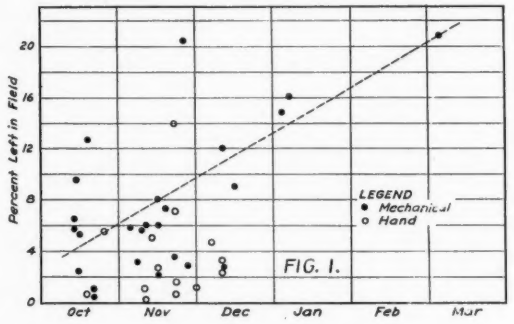
Fig. 1 shows the foregoing results plotted against date of picking. Although not enough data has been collected to indicate the numerical relationship, there is sufficient to indicate that the amount left in the field increases with the age of the season. This can be explained by the fact that early in the fall the corn is damp and less brittle. As the date of picking becomes later, the corn becomes drier and the shanks more brittle, with the result that the corn shells easier and the ears knock off more readily. Also the wind and storms have laid low and broken many ears off the stalks.

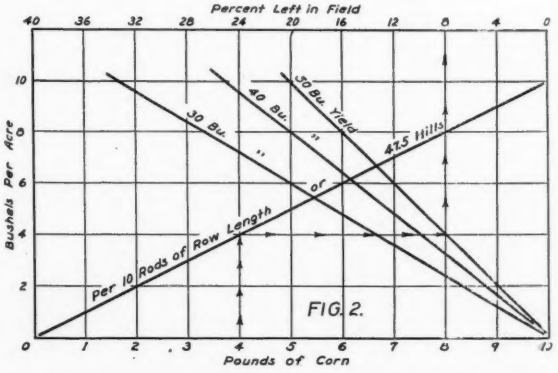
An intelligent decision as to the most practical method of picking corn under a given set of conditions cannot be determined without an appreciation of the comparative percentages of corn left by hand picking and mechanical picking, or without some simple method of making these checks in the field. As a suggestion for determining the amount of ear corn left in field, the curve of Fig. 2 was prepared. In making up this curve the number of hills 3½ feet square on which one pound of corn would be found when one bushel per acre is left, was determined. This was found to be 47.5 hills. It is evident then that, if four pounds of corn is gleaned from approximately 48 hills, the amount left in the field per acre is four bushels, and if the yield is 50 bushels the percentage left per acre is eight. The course marked by the arrows on the figure indicate steps necessary to arrive at this result.

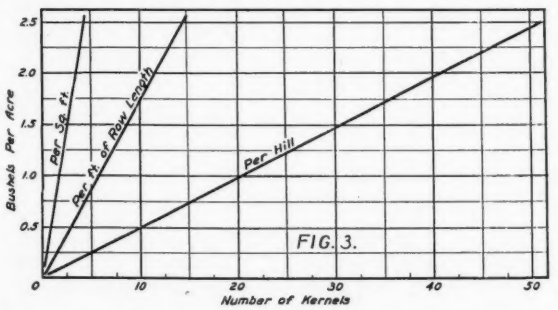
The curve of Fig. 3 is suggested to simplify the checking of shelled corn left by a mechanical picker. It is based

Table I. Results of Three (Hand) Picking Contests

	Percentage left in field			
Year	High	Low	Average	Winner
1928	2.0	0.47	1.13	0.98
1929	3.2	1.13	2.13	1.13
1930	4.1	0.90	1.83	1.60







[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, December, 1930.

[2]Instructor in agricultural engineering, Iowa State College. Jun. Mem. A.S.A.E.

on the formula $Y = X(43,560)$ 72,500 where Y is the bushels per acre, X the number of kernels per square foot, and 43,560 the number of square feet per acre. The figure 72,500 is the number of average-sized kernels per bushel, having been determined by the farm crops department of Iowa State College. As an example illustrating its use, assume 2.5 kernels per square feet left in field, then from the curve, this amounts to approximately 1.5 bushels per acre. Curves for the number of kernels per foot of row length and per hill are plotted to facilitate checking drilled and checked corn.

CONCLUSIONS

1. There is need for further development of the mechanical picker-husker to increase its effectiveness.
2. If a mechanical picker-husker is to be used, it should be used as soon as the corn is dry enough to crib.
3. It would be advisable to pasture the fields where a mechanical picker-husker was used.
4. It is not necessary to carry the curve to the field.

Checks on the amount of corn left can be made by remembering that each pound of corn gleaned from 10 rods of row length, or 48 hills, represents one bushel and that an average of 20 kernels per hill also represents one bushel.

AUTHOR'S NOTE: The author wishes to acknowledge the assistance of Prof. E. G. McKibben; much of the data used in this discussion was accumulated by him.

The Development of a Corn Combine[1]

By C. A. Logan[2]

WE HAVE been using the combine for a good many years to harvest wheat and other small grains, but only recently have we seen the development of a combine designed especially for harvesting corn. The regular wheat combine has been used in several instances to combine corn. The best operation has been obtained in eastern Colorado, western Kansas and Nebraska where the corn is comparatively short and light. However, in general it has proved unsatisfactory due to its inability to properly gather the corn and to its light construction. Corn, being a much heavier material, requires sturdier gathering and threshing devices than do the small grains such as wheat and oats. The combine (Baldwin) referred to in this paper is a machine that gathers, shells and cleans the corn in one field operation.

Since this corn combine has been on the market for just a little over one year, very little authentic information has been obtained in regard to its operation. In fact, so few machines were in operation in Kansas this fall that it was impossible for the author to observe a machine under working conditions in the field without traveling some three hundred miles or more.

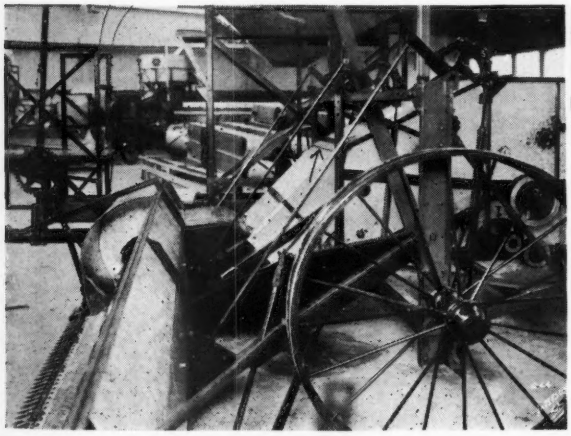
For several years the manufacturer of this combine had been studying the problem and trying to develop a machine that would harvest corn with a combine. They had been having very discouraging results, until one day they happened to think of a long-forgotten order from a farmer in Texas. This farmer had sent in an order for a new rasp-bar cylinder for his combine. An order of this kind being very unusual, they immediately wired to find out why he needed such a repair. The answer was that the combine was being used to shell corn, and the cylinder designed for wheat had worn out. This order gave them the idea that perhaps the combine which they were already building could, with a few changes, be made to harvest corn. Consequently in the fall of 1929 the first corn combine was built and tried out. The first machine used a reel and sickle for gathering and delivering the corn to the conveyor. This was not very successful and a change was made eliminating the reel and using gathering chains. The sickle was replaced with four circular saws working in pairs to make a two-row gathering unit. The present machine uses this arrangement with an auger conveyor delivering gathered material to the cylinder.

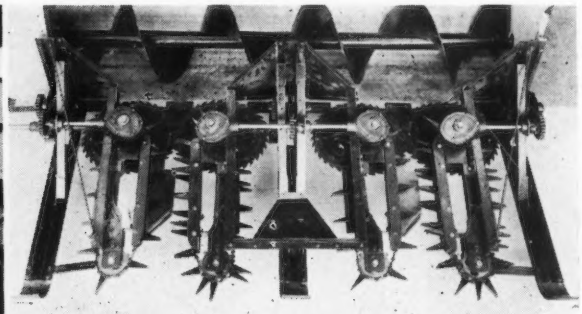
The wheat or small grain combine can be changed to the corn combine in a relatively short time. The change that is necessary in order to make the wheat machine into a corn combine is the replacement of the harvester cylinder unit. This unit consists of the cutting, conveying, feeding, and threshing units, or, in the case of the corn combine, the shelling cylinder and the first or thresher raddle. The remainder of the combine is the same as is used for wheat.

The cylinder for the corn machine, in addition to being made heavier, is run at a recommended speed of 900 rpm instead of 1250 rpm as used in combining wheat. This machine is unique in that all canvases have been eliminated and an auger conveyor is used to deliver the material to the shelling or threshing cylinder. In the case

[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, December, 1930.

[2]Agricultural engineer, Kansas State College. Assoc. Mem. A.S.A.E.





(Left) This shows the framework of the Baldwin combine, the arrow points to the place where the wheat unit is detached to be replaced with the corn unit when using the machine as a corn combine. (Above) This shows the new type of gathering chains which will replace those formerly used

of the corn unit, the corn is cut by the rotating circular saws, then falls into the auger conveyor and is delivered directly to the shelling cylinder.

The wheat combine sells for $1380.00, the corn combine for $1675.00, or the combination machine for $2025.00. The detachable corn unit alone sells for $670.00, or approximately the price of a two-row picker. These prices are f.o.b. factory. The combine comes equipped with a Model A Ford industrial engine and can be pulled with a 15-30-hp tractor.

Due to the fact that the corn combine has been on the market for only one year, very few tests have been made in Kansas. The tests that have been made were conducted under such adverse conditions that we have very little information on which to base our estimate of the success of this machine.

A demonstration was held at Liberal, Kansas, on May 5, 1930. A heavy rain had fallen on May 3 and much of the stalks and corn was still damp at the time of the test.

Mr. F. A. Waggner, superintendent of the Garden City Experiment Station, a branch of the Kansas State Agricultural College, attended the demonstration and the following comments are from his report: "The machine really did a much better job of harvesting and shelling under the conditions it had to work than it was expected it would be able to do. The circular saws did their work in good shape and the machine was able to get practically all of the standing corn. Stalks that were down at right angles to the row, or that were leaning toward the machine, were well taken care of, but stalks leaning away from the machine in the direction of travel were very often cut off and dropped on the ground. All of the corn was not shelled from the cob, nor did it shred many of the stalks. However, in the opinion of several farmers who had had previous experience in shelling corn with the ordinary sheller, the combine was removing as much of the grain from the cob as the ordinary corn sheller would do, when condition of the corn and cob were taken into consideration. No atempt was made to determine the yield and percentage of loss."

In a test at Stratton, Nebraska, on May 23, 1930, the five judges of the test reported that the cost per acre was $1.15 and the cost per bushel 3.22 cents. This was merely the operating cost and did not include overhead charges. The machine was pulled at the rate of 2½ miles per hour and the corn made 35 bushels per acre. No check was made of the percentage loss. In the estimation of one judge, the percentage loss was 2 to 3 per cent and less than hand pickers would leave. Another estimated from 10 to 15 per cent was left in the field. However, a great deal of the corn was down on the ground due to its remaining in the field all winter, and the large crowd tramping through the field.

Mechanically the corn combine is, and will be, a success. Of course there are likely to be improvements in the efficiency with which the corn is gathered, shelled and cleaned. All of our mechanical harvesters have room for improvement in this line. However, these are mechanical details which will be worked out through study and research. The corn combine on which we have so little authentic information presents a fine field for the research engineer.

Practically, the success of the corn combine is still in doubt. No matter how successfully the corn is harvested, unless we can store the shelled corn so that it will keep, the corn combine will never become universally used. Granting that in some years it is just as profitable to market corn at harvest time as to hold it several months for higher prices, it is reasonable to believe that, if great quantities of damp corn should be dumped on the market at harvest time, the price would be very low due to the inability of the terminal elevators to handle the corn with present facilities. In addition, a big majority of the farmers in the corn belt states are livestock farmers and must of necessity store their corn for feeding purposes. According to information gathered by the U. S. Department of Agriculture based on corn receipts at Baltimore, Chicago, and New Orleans, the market corn in November and December averaged 19 to 20 per cent moisture. Shelled corn, to be safely stored, should have a moisture content of about 14 per cent. Therefore before the corn combine can be considered practical for the majority of farmers, some economical method of conditioning the corn for safe storage must be devised. A study by Walter G. Ward at Iowa State College during the past year, on the storage of corn in tight bins brought out some interesting facts in regard to storing shelled corn. Some of his conclusions having a bearing on this subject are as follows:

1. At harvest time the cob contains a much higher moisture content than the shelled corn.
2. Market corn may be conditioned with unheated air if favorable days are used for blowing.
3. Power requirements for blowing corn are reasonable. The greatest efficiency is obtained with low velocities. Good results were secured moving the air through the bin at the rate of 10 feet per minute.
4. Shelled corn dries more quickly than ear corn. The shelled corn reached equilibrium after three days blowing, while the ear corn required about ten days.
5. If it is found practicable to condition the shelled corn instead of on the cob, the storage buildings for corn could be reduced one-half in size, and the saving thus effected should be more than that needed for the installation of suitable conditioning equipment.

The future, then, of the corn combine appears to rest with the ability of the plant breeders to develop a type of corn which can be shelled and safely stored at harvest time, or with the engineers' ability to develop some practical means of conditioning at the time of or after storage. Considerable advancement along the latter line has taken place already.

CONCLUSIONS

1. Mechanically, the corn combine is past the experimental stage and appears to be a little too far advanced for our present methods of corn storage.
2. The majority of corn is not ready to store as shelled corn at harvest time.
3. The corn combine delivers the corn in the field in a marketable condition, eliminating the step of shelling as ordinarily practiced.
4. The combination corn and wheat machine provides a dual-purpose combine which can be used more days throughout the year. This will lessen the overhead charges for the farmer raising considerable quantities of corn and small grains.
5. The stalks, after passing through the machine, are placed back on the field in such a manner that the field is left in good condition for the following tillage operations.
6. If the stalks prove of value for commercial uses, as present conditions lead us to believe they will, it would be a comparatively simple matter to collect the stalks behind the combine.
7. We need a great deal more information in regard to the combining of corn. The research engineers have a great opportunity for study on the mechanical efficiency of the combine, the conditioning and storage of shelled corn, and the salvage of corn stalks for commercial use.
8. A new design of gathering unit placed on the market within the past few days will probably greatly increase the efficiency with which down corn is picked up.

Concern for Man and His Fate[1]

IT IS not enough that you should understand about applied science in order that your work may increase man's blessings. Concern for man himself and his fate must always form the chief interest of all technical endeavors, concern for the great unsolved problems of the organization of labor and the distribution of goods—in order that the creations of our mind shall be a blessing and not a curse to mankind.

[1]From an address by Dr. Albert Einstein to the students of California Institute of Technology.

Irrigation in Western Oregon

By M. R. Lewis[1] and Arthur King[2]

PARTS of western Oregon have been farmed in the past, without irrigation and are popularly supposed to be extremely wet. In 1929, however, approximately 5000 acres in that region were irrigated.

Two factors probably account for the relatively rapid spread of the practice in recent years in this section. One is the uniform dryness of the summers, and the second is the proximity of areas that normally are irrigated. Irrigation, to the Willamette Valley farmer, is not a strange practice carried on only in the deserts of the far west, but is the normal procedure of his friends just over the Cascade Mountains to the east. His daily and farm papers carry much news of irrigation projects and discuss the problems of the irrigated farm as freely as they do those of the non-irrigated sections.

With exact knowledge of the water-holding capacity of each soil, and the water requirements, cost of production with and without irrigation, and returns which may be expected from each crop, it would be possible, presumably, to determine under exactly what climatic conditions irrigation would be profitable. Since such exact information is not available and, more especially, since the type of crop which will be grown on any particular farm in future years is unknown and climatic conditions vary markedly from season to season, no exact determination of the need for irrigation can be made.

Two general methods may be used for estimating this need: (1) Known water requirements of crops may be used in determining whether the effective rainfall, as disclosed by available records, is sufficient to assure profitable crop yields in the locality under consideration; (2) various crops upon which the farmer must depend may be actually irrigated and the results compared with non-irrigated crops raised under otherwise similar conditions.

Water Requirement Method. The study of the water requirements of crops was first systematically undertaken by the irrigation investigations branch of the office of Experiment Stations, U. S. Department of Agriculture, in cooperation with the state agricultural experiment stations, and many investigators have taken part in such studies. Among them Powers[3] has carried on a long series of experiments at Corvallis on the duty of water with various crops, and in these experiments he has determined their water requirements. Widtsoe[4], with his associates, has done similar work for many years at Logan, Utah. Both have studied the use of water by crops under field conditions and determined the evapo-transpiration ratios.

Since it is impossible in field operations to do away entirely with evaporation losses from the soil, it is better to use data based on field trials. Table I shows the water required for the production of normal yields of crops based on the water requirement as determined by Powers and Widtsoe separately.

Perhaps the most striking thing shown in Table I is the extremely small amount of water required for potatoes and corn silage. In the Willamette Valley, as will be noted later, both of these crops show material increases in yields under irrigation.

In general, the soils of western Oregon are not very deep and their storage capacity is therefore limited. It seems reasonable to assume that under these conditions little moisture will be used by such crops as potatoes, pasture, truck crops, and small fruits below the second foot. If we assume that the useful water-holding capacity of the soil is 1¾ inches in depth of water per foot depth of soil, the crop will then be able to use only 3½ inches of soil moisture retained from the winter rains.

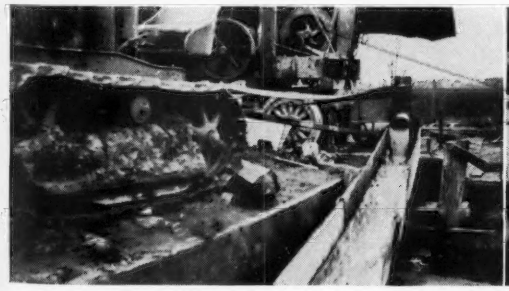
Deeper rooted crops, as clover, alfalfa and trees, will probably use water from 3 to 4 feet, in which case they would have available 6 or 7 inches of soil moisture.

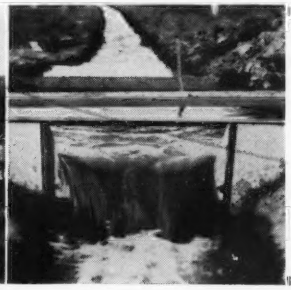
Table II is a summary of the annual and summer rainfall as it occurs at five representative stations distributed throughout the Willamette Valley. This table shows that there is a deficiency of rainfall during the months of May, June, July and August, in this section the growing season for many crops. The mean for the four-months' period shows that during the growing season a very small amount of water is added by natural precipitation to the soil moisture supply. That a droughty 60-day period, occurring during the growing season, may normally be expected is shown under the heading, "Mean for 60-day period," giving the mean precipitation for the driest period of two consecutive calendar months within the four-month period.

Table I. Water Required for the Production of Crops

Crop	Yield	Water Requirement (Evapo-Transpiration Ratio)	Water Required Inches in Depth
Corn silage	12 tons[b]	295[a]	9.4
Potatoes	200 bu[c]	594[a]	7.9
Carrots	25 tons[e]	423[d]	14.0
Barley	50 bu	513[d]	10.7
Oats	60 bu	596[d]	8.3
Wheat	30 bu	856[e]	15.3
Alfalfa	5 tons	801[a]	35.4
Clover	5 tons	584[a]	25.8
Grass	4 tons	522[a]	18.5

[a]Data from Powers
[b]Containing 70 per cent moisture
[c]Containing 75 per cent moisture
[d]Data from Widtsoe
[e]Containing 85 per cent moisture.





(Left) Testing well with tractor and temporary pump in Willamette Valley. (Right) Discharge from irrigation well in Willamette Valley flowing over a two-foot weir

[1]Irrigation engineer, department of soils, Oregon Agricultural Experiment Station; and agricultural engineer, division of agricultural engineering, Bureau of Public Roads, U. S. Department of Agriculture. Mem. A.S.A.E.

[2]Extension specialist in Soils, Oregon State Agricultural College. Assoc. Mem. A.S.A.E.

[3]Powers, W. L. The Economic Limits of Pumping for Irrigation. Bulletin No. 235, Agricultural Experiment Station, Corvallis, Oregon, 1928.

[4]Widtsoe, John A. The Production of Dry Matter with Different Quantities of Irrigation Water. Utah Agricultural Experiment Station Bulletin 116, 1912.

Table II. Willamette Valley Precipitation Data[a]

	Corvallis	Eugene	McMinnville	Portland	Salem
Number of years of record	39	36	37	57	35
Number of years in which more than 5 inches fell in the period May to August, inclusive	11	16	12	31	11
Number of years in which more than 5 inches fell in the period May to August, and in which over 2 inches fell in 60-day period	1	2	2	8	2
	Inches	Inches	Inches	Inches	Inches
Mean, annual	41.90	38.08	43.92	41.78	37.80
Mean, May to August, incl.	4.01	4.96	4.18	5.12	4.18
Mean for 60-day period[b]	0.58	0.72	0.79	1.11	0.66
Maximum, May to August, incl.	7.85	10.29	7.83	11.50	7.57
Minimum, May to August, incl.	1.56	1.63	1.36	1.94	1.12
Maximum for 60-day period[b]	2.37	4.23	3.00	3.51	3.07
Minimum for 60-day period[b]	0.00	0.00	0.00	0.00	0.01

[a]From U. S. Weather Bureau records.

[b]The 60-day period here considered comprises the two consecutive calendar months having the least rainfall in each year.

The lack of moisture during the growing season is further emphasized in the data showing the number of years in which more than 5 inches of moisture fell during the period, May to August, inclusive. The 5-inch basin is an arbitrary basis of comparison, but it is thought to be about the minimum amount of precipitation which would be effective when spread over this period. If we assume a minimum of 5 inches for the four-months' period, and further limit ourselves by assuming that not less than 2 inches of rainfall should occur during any 60-day period in order to keep a crop from suffering we find that the Willamette Valley is extremely dry. This is indicated in the last line of Table II.

The figures in Table II represent total rainfall. It is probably safe to assume that at least 50 per cent of this moisture is lost without adding to the soil moisture, since much of the total is made up of small showers of one-half inch or less in 24 hours. In any case, Table II shows that the summer months are very dry, even though total amounts are used.

Table III shows the water requirements of various crops, the probable amount of moisture these crops may secure from the soil, the deficiency to be made up by rainfall or irrigation, the average of the means of precipitation for the period May to August for all stations shown in Table II, the deficiency above this mean, and the number of years there was no deficiency in moisture for these crops at Corvallis. From the data shown in this table, it may be assumed that irrigation would be beneficial to carrots, wheat, alfalfa, clover, and grass every year out of the 39 years of records at Corvallis.

Here, again, the comparisons are made using the total rainfall. If effective rainfall data were used, the need for irrigation of the crops shown in this table would be further emphasized. This will be substantiated by yield data shown later.

It was shown in Table II that a dry two-month period could be expected during practically every season. Irrigation, then, could be expected to be of benefit to potatoes even though the total rainfall, if it were all effective, supplied more than an ample amount of moisture.

Irrigation Trial Method. Field experiments on the results of irrigation in the Willamette Valley have been carried on since 1907. In that and the two following years, Stover[5] working under the direction of Dr. Samuel Fortier, of the U. S. Department of Agriculture, conducted trials on

Table III. Water Required, Available and Deficient in Acre-Inches for Various Crops in the Willamette Valley from Data in Table I and II

Crop	Water required	Soil storage	Water required from rainfall and irrigation	Mean rainfall, May to August, inclusive	Mean deficiency	No. years in past 39 with no deficiency at Corvallis
Corn silage	9.4	5.2	4.2	4.5	—0.3[a]	15
Potatoes	7.9	3.5	4.4	4.5	—0.1[a]	14
Carrots	14.0	3.5	10.5	4.5	6.0	0
Barley[b]	10.7	5.2	5.5	4.5	1.0	9
Oats[b]	8.3	5.2	3.1	4.5	—1.4[a]	27
Wheat[b]	15.3	5.2	10.1	4.5	5.6	0
Alfalfa	35.4	7.0	28.4	4.5	23.9	0
Clover	25.8	7.0	18.8	4.5	14.3	0
Grass	18.5	3.5	15.0	4.5	10.5	0

[a]On the basis of the total supply of water for the four-month period, May to August, these crops should have a sufficient supply of water in normal years.

[b]Spring-sown crops are considered in this table. Fall-sown crops generally mature on winter rainfall.

the effect of irrigation on a large variety of crops. In each case where a comparison is possible, substantial increase in yield, ranging from 27 to 180 per cent, were secured by irrigation.

A part of the work done by Stover was carried on in cooperation with the Oregon Agricultural Experiment Station at Corvallis. Since 1910, these experiments have been continued by the experiment station, and the results reported in a number of bulletins and technical articles by Dr. Powers and others of the staff. These experiments have shown conclusively that increased yields of most, if not all, of the usual field crops of the Willamette Valley, excepting winter crops of the small grains, can be secured by irrigation. Table IV shows the results obtained in this work.

In recent years the experiments have been extended to include pasture, garden vegetables and small fruits. The possibility of profit seems to be better with these than with field crops. At present, popular interest in irrigation in the Valley is largely confined to the production of forage, truck, and small fruit crops. Dairying, one of the principal agricultural enterprises of the area, has been very seriously handicapped by the lack of pasture of other succulent feed during the late summer and early fall. The use of irrigated ladino clover pasture meets this problem very satisfactorily. On the experiment station farm, land which formerly was practically worthless except for low-grade grazing for a few weeks in spring and fall, when thus farmed, carried 3.74 cows per acre during the six-months' pasture season. This return was equivalent to 17 pounds of alfalfa hay, or 10 pounds of alfalfa hay and 19.33 pounds of corn silage a cow per day. In other words, each acre of pasture produced feed equal to 5.73 tons of alfalfa hay, or 3.37 tons of alfalfa hay and 6.50 tons of corn silage[6].

For the past 4 years, experiments have been conducted on the irrigation of strawberries and cane fruits. Curiously, one variety of strawberries, the Ettersburg 121, shows a slight decrease in yield by reason of irrigation. All other berries showed increases of from 45 to 110 per cent in total yield. In addition to the increase in total yield, the irrigated berries were larger and, to that extent, better. In other respects irrigation had no material effect on the quality of berries. Even in the case of the Ettersburg strawberry irrigation has been of value as it has made it possible to save one year in establishing the crop. Without irrigation new plantings are made in the spring and no crop is harvested until the next year. With irrigation the planting may be made in the fall after the harvest of an early maturing crop, such as grain, and a crop of berries secured the next spring. In at least one instance, also,

[5]Stover, A. P. Irrigation Experiments and Investigations in Western Oregon. Bul. 226. Office of Experiment Stations, U. S. Department of Agriculture. 1910.

[6]Jones, I. R., and Brandt, P. M. Irrigated Pastures for Dairy Cattle. Bul. 264, Oregon Agricultural Experiment Station. 1930.

A dry growing season may make irrigation profitable even in areas of heavy annual rainfall. Increasing recognition of this fact is resulting in increased use of water resources for irrigation

a commercial grower has secured an increase in yield and size of Ettersburg strawberries. A report on this experiment, giving a careful analysis of all costs and returns, is being prepared for publication as an experiment station bulletin by R. S. Besse and G. L. Rygg.

Area Suitable for Irrigation. The survey of the soils of the Valley show that there are 1,250,000 acres of tillable soils in the Valley floor and that the greater portion of this area is topographically suitable for irrigation. Some areas along the main streams are too rough for surface irrigation, but the soils of these areas are in general suitable for intensive cropping and may be irrigated by sprinkler systems. About 500,000 acres of the Valley floor have free working soils of smooth topography which have been shown to be suitable for a large variety of crops under irrigation. The rest of the irrigable area is made up of heavier soils, which may be not suitable for many cultivated crops but are suitable for irrigated pasture.

The total area of the Willamette watershed is 11,200 square miles of which an area of 4,840 square miles is above Albany, Oregon. The mean flow of the Willamette River at Albany for the period 1900-1929 was 13,700 cubic feet per second, or about 10,000,000 acre-feet per year. With the same run-off per square mile, the annual discharge of the river into the Columbia would approximate 23,000,000 acre-feet, or 18 acre-feet for every acre of irrigable land. It is evident that there would be sufficient water to irrigate all the irrigable lands of the valley if adequate storage and distribution systems were provided. That storage will be required is shown by the fact that the whole flow of the river is now used during low-water periods by paper mills and power plants at Oregon City.

For the present, there seems to be little prospect of the construction of large gravity systems involving extensive canal systems and storage reservoirs. The farmers generally are not yet convinced that irrigation would be profitable. Until the practice becomes more general, it is doubtful if a majority of the landowners in any large tract would agree to pay the cost of such systems.

Until such large projects are feasible, irrigation will be carried on in small units. In many cases, such small units can be irrigated by gravity flow from small streams entering the Valley from the foothills. Other small units may be irrigated by pumping water from ponds and the larger streams to adjacent lands. The larger part of the lands are so situated that they can not be reached in this way, and such lands will probably be irrigated in the near future, if at all, by pumping from the ground water.

Use of Ground Water. The U. S. Geological Survey, in cooperation with the Oregon Agricultural Experiment Station, has made a survey of the Valley to secure definite and reliable information as to the areas in which ground water could be secured in quantities sufficient for irrigation without too great cost for drilling or for pumping. The field study was made by Arthur Piper, associate geologist, U. S. Geological Survey, during the summers of 1928 and 1929. Mr. Piper is now preparing a report of this survey.

The studies show that water is generally available in the newer alluvium of the river bottoms and in older alluvium under rather considerable areas of the old Valley floor. In some cases, more extensive drilling will have to be done before it is possible to locate the boundaries of these areas definitely.

This study of ground water conditions is especially important in view of the fact that much of the present interest in irrigation is concentrated on the use of irrigation water for pasture. As the pastures will, in the main, be irrigated by surface flooding, it will be necessary to have a fairly large supply of water. Experience in the irrigated sections indicates that a stream of at least one cubic foot per second (450 gallons per minute) should be available if pasture irrigation is to be done without loss of water or of time in irrigating.

On the other hand, small areas of truck crops and small fruits may be successfully irrigated by the use of smaller streams. This is especially true if sprinkler systems are used. It therefore seems probable that satisfactory supplies for the irrigation of these crops can be developed over a somewhat larger area than can supplies satisfactory for pasture irrigation.

Fund for Development. During the last few years, interest in irrigation in the Willamette Valley has been very keen. Since the use of deep wells for irrigation has not been practiced in the Valley, and since the farm units are in the main comparatively small, it seemed desirable to arrange for demonstrations of the feasibility of such irrigation. With this end in view, a number of individuals and other agencies interested in the agricultural development of the Valley have subscribed a revolving fund of several thousand dollars to be expended under the direction of the Oregon Agricultural Experiment Station in the development of deep-well irrigation.

The first system installed is a well of the California stove pipe type, 155 feet deep and 18 inches in diameter. The well is equipped with a deep-well turbine pump having a capacity of 900 gallons per minute against a total head of about 70 feet. Since the farm on which the system has been installed is not particularly well adapted to irrigation, in that the topography is rough and that leveling is prohibited by the orchards already planted, it has been necessary to install a comparatively expensive underground pipe system to distribute water. During the season of 1930 this system has been constructed for a total of 53 acres. Of this area there were approximately 35 acres in cane fruits and 10 acres in cucumbers. The rest produced a variety of crops.

During the 1930 season 79.6 acre-feet of water were applied to 52.8 acres. The cost of electric energy for pumping was $4.47 per acre, or $2.97 per acre-foot. The cost of water at the well, including fixed charges on the well and pump, amounted to $11.29 per acre, or $7.49 per acre-foot. If the pump had been operated 16 hours a day for the

Table IV. Results of Irrigation by the Oregon Agricultural Exreriment Station at Corvallis. General crops 3 to 20-year averages; old irrigation plots. (Willamette silt loam—Valley floor)[a]

Crop	Not irrigated		Irrigated		Increase by irrigation	
	Yield	Value	Yield	Value	Yield	Value
Potatoes	130 bu	$117.00	191 bu	$171.90	61 bu	$54.90
Alfalfa (hay)	3.5 tons	42.00	6.0 tons	72.00	2.5 tons	30.00
Clover (hay)	4.6 tons	55.20	6.6 tons	79.20	2.0 tons	24.00
Grass (hay)	3.3 tons	39.60	5.1 tons	61.20	1.8 tons	21.60
Beans	10.8 bu	38.88	15.6 bu	56.16	4.8 bu	17.28
Kale	10.6 tons	53.00	14.0 tons	70.00	3.4 tons	17.00
Corn (silage)	6.4 tons	32.00	9.2 tons	46.00	2.8 tons	14.00

[a]The economic limit of pumping for irrigation. Oregon Agr. Expt. Sta. Bul. 235 (Data from Table I, p. 14.).

period June 15 to August 31, 130 acres might have been irrigated. The cost then for power and fixed charges would have been $5.96 per acre, or $3.87 per acre-foot. As has been stated, the cost of the distribution system is comparatively high. This has affected the cost of water as applied to the land. The total cost of water applied to the land was $30.10 per acre, or $19.96 per acre-foot. Again, if this plant had been used more nearly to its full capacity, the cost would have been reduced to $21.28 per acre, or $14.09 per acre-foot. The owner plans to get the whole farm under irrigation within the next few years. The lower cost noted above would then be in effect. It is possible, indeed, that a still lower cost may be secured by using some water from this equipment on adjoining land.

Other Recent Developments. During the 1930 season, the county agent of Yamhill County has made supplementary irrigation his major project. In cooperation with the Oregon Committee on the Relation of Electricity to Agriculture and the Yamhill Electric Company, some thirteen farmers in Yamhill County irrigated during that season.

During the same season an extension specialist in soils worked in the field, and a very large part of his time was devoted to irrigation. He assisted approximately one hundred farmers in planning irrigation systems and most of these systems will be put into operation during the coming year. It is estimated that the various divisions of the state agricultural college have assisted some 150 farmers to plan irrigation systems covering approximately 3,000 acres of land during the last two years.

Applications for water rights from the Willamette River and its tributaries during the last three years have totalled 61,094 acres. Approximately half of this area is taken up by three rather large developments which are somewhat problematical. The other half consists of a very large number of individual farms, a large part of which have been developed or will be developed within the next two years. These facts seem to indicate that irrigation in the Willamette Valley is coming into its own and will become more or less standard practice on truck crops, small fruits, and for dairy pastures.

There are a number of smaller valleys west of the Coast Range in Oregon where dairying is by far the most important agricultural enterprise. These valleys have more rainfall than the Willamette Valley. However, as in the Willamette Valley, the rainfall during the summer months is very light. In each of these valleys, a little supplemental irrigation is now practiced and there seems every prospect that the area so irrigated will increase as years go by. If this is done we shall have the rather surprising condition of considerable supplemental irrigation being employed in areas where the normal annual rainfall is from 60 to 100 inches per year.

Paper Pulleys and Cast-Iron Pulleys in Belt Power Transmission[1]

By C. A. Norman[2]

IN THE investigation of the relative transmissive capacity of paper pulleys and cast-iron pulleys, Station Project No. 35, a research on power transmission by means of belting, which has been going on for years in the department of mechanical engineering, has attained at least a temporary stopping point.

This research was begun in an attempt to check up certain unfavorable opinions about the transmissive power of rubber belting. The fact was confirmed that the tractive power of a rubber belt on cast-iron pulleys was somewhat less than that of a well run-in oak-tanned leather belt. In other words such a leather belt could be run slacker than a rubber belt, and yet transmit its power without undue slip. It was also established, however, that when oak-tanned leather belt was new, it did not do so well as a rubber belt. Moreover, rubber belts could, without any very excessive amount of tightening, be made to transmit a great deal of power without undue slip, although of course the degree of tightness required was somewhat greater than that needed for the well run-in leather belt.

This first research was carried out by means of short strips of leather belting laid over a slowly revolving pulley, the frictional pull being measured by a spring balance. This method was challenged by certain critics who claimed that results obtained by this method would not check with those from actual running belt drives. It became advisable to repeat the tests with running belts. A rather comprehensive series of investigations was therefore undertaken by G. N. Moffat and C. A. Norman in the summer of 1927. The results were published in 1928 in Bulletin 41 of the Engineering Experiment Station. On the whole a good agreement with results from earlier tests was established. The results were given wide publicity.

The experimenters did not feel that their task was completed until they had ascertained whether the transmissive power of rubber belting could not be improved by the use of some pulley material other than iron or steel. They therefore welcomed an opportunity to investigate the transmissive power of Rockwood compressed-paper pulleys. Both oak-tanned leather belts and rubber belts were run on these pulleys and it was found that the transmissive power of the latter could indeed be much improved by the use of pulleys of this kind. The pulleys had a beneficial influence also on the transmissive power of oak-tanned leather belts. The tests were carried out not only at arc of contact approximating 180 degrees, but also on arcs even as small as 90 degrees. It was found that the paper pulleys were of particular value in improving transmissive efficiency with small arcs of contact.

The tests published in 1928 did not cover high overloads, nor did they cover the mechanical efficiency of the drive. In the tests just finished the effective pull on the belt was carried to 100 pounds per inch of width, which means an overload of about 100 per cent for a single leather belt or a four-ply rubber belt. It was found that both rubber belts and leather belts were able to transmit such high loads on both cast-iron and paper pulleys when the diameter was 18 inches. In the earlier tests such high overloads were within the range of the machinery only when very small pulleys were used, and these small diameters had of course an unfavorable effect on the transmissive power of some of the belts.

The determination of mechanical efficiency did not show anything that was not known before. A belt transmission has a mechanical efficiency of say, 95 per cent or better on pulleys of sufficiently large diameter. The loss is made up partly of so-called "creeps" of the belt over the pulleys, and partly of internal work in flexing the belt over the pulleys. The creep is proportional to the load and remains a fairly constant percentage of the load under all conditions. The internal flexing work is, however, rather independent of the load and hence forms a smaller percentage of a large load than of a small load. Hence the mechanical efficiency of a belt drive goes up not only with the diameter of the pulleys, but also with the load.

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[1]Reprinted from the Ohio Engineering Experiment Station News, Vol. III, No. 1.

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Agricultural Engineering Digest

A review of current literature on agricultural engineering by R. W. Trullinger, specialist in agricultural engineering, Office of Experiment Stations, U. S. Department of Agriculture. Requests for copies of publications abstracted should be addressed direct to the publisher.

Simple Test for Impurities in Sand to be Used for Concrete on the Farm, D. G. Miller and P. W. Manson (Minnesota University (St. Paul) Agricultural Extension Circular 34 (1930), pp. 4, fig. 1).—This test is described briefly. It consists essentially of observing the dissolution of organic impurities in the sand in a solution of lye as an indication of the amount of such impurities present.

Notes on Strength of Timbers, with List of Transverse Tests on Specimens in the Technological Museum, M. B. Welch (Technological Museum, Sydney (Australia) Bulletin 13 (1929), pp. 21).—Information is given on various factors affecting the strength of timbers, and data on the physical and mechanical properties of different woods are included.

Measuring Irrigation Deliveries in the Panjab, E. S. Lindley (American Society of Civil Engineers (New York) Proceedings, 57 (1931), No. 2, pp. 269-283, figs. 3).—The paper describes the conditions of Indian canals as affecting the problem of distributing the supplies received in the manner desired. It describes the devices available for affecting such distribution with a minimum of manual control, mentions their principal qualities, and refers to the records of investigations directed to their improvement. An outline is given of the theories on which to base design in using such devices to form a complete scheme of automatic distribution, and, finally, their practical application is discussed in so far as they are found possible under present limitations of knowledge and invention.

The method and means of measuring and apportioning irrigation deliveries that are in course of development in India, and especially in the Panjab, are described.

The Automatic Underfeed Coal Stoker for Domestic Heating, H. J. Dana (Washington State College, Engineering Experiment Station (Seattle), Engineering Bulletin 27 (1929), pp. 19, figs. 6).—This equipment is briefly described and diagrammatically illustrated, and the results of service tests are reported. They indicate that, by installing an automatic underfeed coal stoker, the coal will be burned much more efficiently and therefore a smaller amount of coal will be consumed during the season. Actually, however, the added ease and convenience of heating a residence with a stoker serves to induce the owner to maintain himself more comfortably and for a great part of the 24 hours, with the result that he will probably burn about the same number of tons of coal as by the usual hand-firing methods. The grade of coal used in the stoker, however, costs from 30 to 40 per cent less than lump coal for hand firing.

Farm and Industrial Tractors, D. N. McHardy (London: Crosby Lockwood & Son, 1930, pp. XVI + 244, figs. 73).—This is a handbook of information on tractor operation, care and use for both farming and industry from the English viewpoint. It contains chapters on early development, British tractor trials, the internal-combustion engine, valve operation, fuels and carburetion, ignition, lubrication, cooling systems, transmission systems, chassis design and running gear, crude oil engines, driving, maintenance, possible sources of trouble, the organization of farm work, plowing, tillage work, drilling, haying and harvesting, belt work, farm haulage, costs of operation, the horticultural tractor, industrial types, trailers and equipment, and some industrial applications.

Heat Power, E. B. Norris and E. Therkelsen (New York and London: McGraw-Hill Book Co., 1930, pp. XIII + 376, figs. 257).—This book deals with the principles of heat power. It contains chapters on the internal-combustion engine, internal-combustion engine details, fuels for internal-combustion engines, principles of combustion, work and power, heat and work, analysis of internal-combustion engine cycles, actual performance of internal-combustion engines, the steam power plant, steam, steam engine performance, improving steam engine performance, steam engine mechanisms, the steam turbine, condensing equipment, steam boilers, boiler fuels and furnaces, boiler accessories and auxiliaries, and boiler performance.

The Ice Well for the Dairy Farm, J. H. Dawson and A. L. Watt (U. S. Department of Agriculture (Washington, D. C.) Circular 155 (1931), pp. 12, figs. 5).—A description is given of the details of construction of the ice well installed at the U.S.D.A. Dairy Experiment Station at Mandan, N. Dak., together with data from observations made over a period of about two years on this well and one a concrete well at the Dairy Experiment Station at Ardmore, S. Dak.

The ice well at Mandan consisted essentially of a pit 8 feet square and 9.5 feet deep dug in a well-drained site about 10 feet from the milk house and having a bottom of 1.5 feet of coarse stone and gravel. The sides of the pit were lined with cheap, rough lumber; two by four-inch studs were placed upright 2 feet apart against the dirt sides, and rough 1-inch boards were nailed to those. This construction gives a 4-inch air space, if the dirt walls do not cave in. This air space is good insulation against the soil heat. The lumber was not treated in any way, and after two seasons' use there are no signs of rotting.

Ice wells constructed according to the method employed and material used at Mandan are practical and successful under the temperature conditions prevailing in that section. It is thought that such ice wells are adapted to any locality where winter freezing temperatures are sufficiently low and extend over long enough periods to freeze enough ice in the pit. By being careful to conserve the ice, sufficient ice can be made to last over a period of approximately four months during the summer for ordinary dairy-farm use.

In the two experiments described, lumber was the best material for lining the well. Noninsulated concrete was not suitable as used. Milk, cream and butter can be successfully stored in the ice well for reasonable periods of time. No offensive odors result when care and cleanliness are practiced. For small lots of cream, precooling with cold running water is not necessary, but it is desirable. For large lots of cream it is advisable to precool with cold water in order to conserve the ice and to bring about more rapid cooling. It is advisable to precool whole milk before storing it in the ice well. The ice well can be made at low cost. The lumber used in the well can be cheap and rough. The house over the pit should be tight and durable, but it need not be expensive.

Air Cleaners for Motor Vehicles, A. H. Hoffman (California Station (Berkeley) Bulletin 499 (1930), pp. 66, figs. 42).—This bulletin describes and presents the results of tests of 88 different air cleaners for internal-combustion engines. The test results indicate that the proper installation and servicing of a good air cleaner means less engine wear, less trouble, less expense for fuel, oil, repairs, and breakdowns, quieter running, and greater dependability. A cleaner should offer the least possible restriction to the passage of air through it.

Most of the air cleaners now sold, if properly selected as to size for the engines on which they are to be used and if kept clean, do not appreciably affect the power of acceleration of road vehicles at speeds of 40 miles per hour and under. Above 40 miles per hour the effects of high restriction and of insufficient servicing are much more marked. Air inlets should not face the blast from the radiator fan and elbows and long tubular connections should be avoided. Air leaks in the connections between the air cleaner and the carburetor are detrimental. All good air cleaners require some servicing.

Air cleaners of different makes and types differ markedly in their behavior in use. The dry centrifugal type cleaners now marketed do not afford adequate protection. At low air speeds this type loses practically all of its efficiency. Tightly woven or felted dry filters and tightly packed plain oily filters afford good protection, but have often caused trouble from increasing restriction when not sufficiently serviced. Loosely packed plain oily filters usually do not offer much restriction, even if neglected, unless clogged by leaves, chaff, or insects. Many are too thin to afford satisfactory protection; some give excellent protection if sufficiently serviced.

Self-washing oily filters, if well designed and sufficiently serviced, generally afford excellent protection even in extreme dust. This type is well adapted for tractors, large trucks, and busses. Some makes have low restriction, others somewhat higher; some are simple in design, others rather complicated; and in some the washing action is vigorous and effective, in others it is inadequate.

Most air cleaners to some extent muffle carburetor noises. Many of them also serve to minimize the danger of gasoline being ignited by back-fires. The principle of the Davy safety lamp applies, i.e., chilling the burning gases by passing them through small openings in metal or other heat-absorbing material.

Stationary Spray Systems in West Virginia, F. D. Cornell, Jr. (West Virginia Station (Morgantown) Bulletin 239 (1931), pp. 28, figs. 9).—This bulletin reports the results of a study of the details and costs of installation and operation of stationary spraying systems, and of the economy and efficiency of these systems as compared with portable systems in both large and small orchards.

The results point to the necessity of a plentiful water supply and a power unit large enough to maintain proper pressure with some reserve. Copper bearing pipe has certain advantages for use in such a system. Main lines may vary in size from 1 to 2 inches, while laterals should not be less than 0.75 inch. An air chamber of sufficient size is indispensable in the line. Globe valves and special cut-offs are preferred to gate valves. Pro-

vision for drainage should be made at all low points in the line to prevent difficulties resulting from freezing. High-pressure hose with a minimum size of 0.5 inch is recommended for stationary outfits.

The trend in development is toward the use of more pipe and fittings, less hose, and a one-man unit. The economy of this plan has been demonstrated. It eliminates delays in the field occasioned through the use of long hose, decreases labor costs and the difficulty of obtaining reliable help, decreases the possibility of missing trees in spraying, and speeds up the spraying operation. The stationary spray system possesses an advantage in the number of trees it is possible to spray per man hour, as compared with portable sprayers, particularly on systems where a one-man unit is used.

Stationary spray plants are adaptable to every type of topography and are in use now in orchards where portable sprayers could be used only with the greatest difficulty.

The initial cost of the stationary system for orchards of commercial size need be no greater than the cost of complete portable spray equipment for the same orchard.

[Agricultural Engineering Investigations at the Ohio Station] (Ohio Station (Wooster) Bulletin 470 (1931), pp. 205-224, figs. 18).—Investigations by G. W. McCuen and N. R. Bear of mechanical methods of seedbed preparation showed that where disking alone was done in sweetclover the best seedbed was obtained when the clover was disked once and allowed to lie for weeks before final disking. Such preparation did not cause a serious weed problem during the wet year of 1929. Germination of seed was slower on disked and pulverized plats than on plowed plats. Chiseling was more effective in dry years than in wet years. In a dry year four different methods of seedbed preparation were of equal value.

Field tests by R. M. Salter and C. O. Reed of corn planter fertilizer attachments showed that the close proximity of seed and fertilizer resulted in reduced stands, especially notable for the heavier rates with a consequent reduction in yield. The early growth was excellent for the 100-pound rate but was less so at the heavier rates, and actually less than the checks for the 400-pound application.

Placing the fertilizer in a shoe furrow between the hills and at some distance from the seed was safe as indicated by stand, but it had little favorable influence on early growth. The experimental planter developed in an attempt to obtain placement in two lateral 2 by 7-inch bands, one on either side of the seed, separated 3 inches, and approximately 0.5 inch above the seed level, appeared to be both safe and efficient. For all rates the stand was slightly in excess of the check, while early growth was also good with no evidence of retardation at the heavier rates.

Combine investigations by E. A. Silver and Bear showed that cutter bar losses are less when cutting a low or short stubble because of a minimum of heads slipping by under the knife bar. The losses resulting from a thin stand are extremely heavy when cutting high stubble. The percentage of straw breaking in a thin crop is greater than that in a heavy crop. This feature again produces a heavy loss by the drooping heads being cut off and dropping to the ground. This is especially true when cutting a high stubble. An 11 or 12-inch stubble has the best ability to support the windrow where the fingers of the pick-up have a better chance to get under it. On a short stubble the windrow is so close to the ground that the pick-up fingers do not get a chance to get under the windrow for efficient elevation. A windrow on a medium length stubble will also stand up better when heavy rains are experienced. The general conclusion is that with an average crop the threshing losses are less with the higher stubble.

Feed grinding investigations by Silver involved tests of 12 mills of 5 different types, including burr, combination, rigid hammer, triple-reduction process hammer, and swinging hammer mills. The grains and roughages ground were oats, barley, shelled corn, ear corn, alfalfa, corn stover and soybean hay. On each test four runs of from 2 to 7 minutes duration were made, comprising full capacity, three-quarter, one-half and one-quarter capacity.

The results indicate that on fairly coarse grinding the burr mills exceeded the hammer type of mills, but the advantage decreased on fine grinding. On the shelled corn grinding the burr mill ground to the fineness of 3.9, while the hammer mills ground to 3. For ear corn grinding, which has a modulus of fineness of 3, the burr mill began to drop until on the oats grinding, done at a modulus of fineness of 2.7, it reached the lowest efficiency. The temperature of the materials after grinding was very much higher from the burr mills than that from the hammer mills because of friction in the grinding or burr chamber.

The rigid or straight hammer type of hammer mills seemed to excel all the others in efficiency. It was surpassed in the shelled corn grinding by the burr mill and only slightly in the oats grinding by the triple reduction process hammer mill, which cuts the material with knives for the first reduction, then pulverizes the material by heavy, revolving disks or similar devices, and accomplishes the final reduction by the material coming in contact with revolving hammers. The triple reduction process hammer mill showed fair efficiency, while the swinging hammer type of hammer mill and the combination type of burr mill were consistently low in efficiency.

In grinding roughages the straight hammer type of hammer mill ranked well toward the top, surpassed only in soybean hay grinding by the triple reduction process hammer mill. Again, the swinging hammer type of hammer mill and the combination burr mill were consistently low. On fairly coarse grinding such as in the corn stover tests, the combination mill began to show a higher efficiency because it requires less power to cut the material than it does to pulverize it between a set of burrs. The hammer mill required more horsepower above a fineness modulus of 3 and the burr mill required less. Below a modulus of fineness of 3 the burr mill required more horsepower and the hammer mill less.

On shelled corn grinding the burr mill required less horsepower than the hammer mill to any fineness over 2.45. Below this fineness the hammer mill required less than the burr mill. The grinding range for burr mills on shelled corn was much greater than that of the hammer mills. With the lower speeds a more coarsely ground product is obtained with hammer mills, and with the higher speeds a more finely ground product. Very little of the grains—barley, oats, and shelled corn—will pass through smaller than a 3/32-inch screen. The data also indicate that there is very little change in fineness with a screen above the ½-inch size. The greatest variation in fineness occurred with the screens from 3/32 to ½ inch. When no screen was used there was very little difference in the fineness over that when the mill was equipped with the 1¼-inch screen.

Experiments by V. L. Overholt on the use of dynamite in the maintenance of open ditches indicated a higher efficiency for concentrated loading. Dynamite is a quick and easy means of removing obstructions from the channel, and can often be used economically on jobs too small to warrant the use of dredging equipment. It scatters the material, thus avoiding high spoil banks. Dynamite can not be safely used where the ditch passes near buildings or other structures. Best results can be obtained only when the soil is completely saturated, but there should not be a great amount of water in the ditch at the time of blasting. It is necessary to use dynamite sensitive enough to be fired by propagation. Under favorable conditions it will require 0.63 lb., or a little more than one stick of dynamite, to remove 1 cu. yd. of soil.

Ventilation of the Cornell Open-Front Poultry House, F. L. Fairbanks and H. E. Botsford (New York Agricultural College (Cornell) (Ithaca) Extension Bulletin 197 (1930), pp. 12, figs. 11).—Practical information is presented on the ventilation and management of the Cornell open-front poultry house.

Plans for a Simple Milk House, H. E. Ross (New York Agricultural College (Cornell), (Ithaca) Extension Bulletin 200 (1930), pp. 19, figs. 6).—Plans for and a description of a simple milk house are presented, together with a bill of materials.

Progress Report of the Irrigated Eighty-Acre Demonstration Farm Unit of the Harney Branch Experiment Station, 1927-1930, O. Shattuck and R. E. Hutchison (Oregon Station (Corvallis) Bulletin 270 (1930), pp. 38, figs. 6).—This report states that the cost of a suitable engine and pump, installation, etc., in the Harney Valley will vary from $2,500 to $4,000. The pumping cost will vary from $5 to $10 per acre-foot of water. The cost of the distribution system and leveling of land will vary from $10 to $30 per acre. The data upon the cost of producing standard crops under irrigation indicate that these crops can be produced at a satisfactory profit with water pumped from wells within the probable pumping lift in the Harney Valley.

The tract is irrigated from an 18-inch drilled well, 85 feet deep, cased to a depth of 60 feet with 12-gauge galvanized steel casing. A Kimball turbine pump is used, operated by a 25 horsepower semi-Diesel oil engine. The total first cost of the well and pumping plant was $4,134. This includes the weir box, turnouts, and flume, and also the compressed air starting equipment installed in 1930. Leveling and constructing permanent ditches cost $16.03 per acre up to 1930.

For the 4 years the average annual application of water was 1.27 acre-feet per acre of crop. After allowing all costs of production, including depreciation of equipment and pumping plant, the crops grown on the demonstration farm unit gave a return on the capital investment of 11.6 per cent in 1927, 5.6 per cent in 1928, 47.9 per cent in 1929, and 8 per cent in 1930, averaging 18.2 per cent for the 4 years. The most promising crops for the conditions of this demonstration seem to be alfalfa hay, wheat intercropped in row alfalfa producing seed, and potatoes.

Torrential Floods in Northern Utah, 1930 (Utah Station (Logan) Circular 92 (1931), pp. 51, figs. 24).—This is the report of a special flood commission appointed by the Governor of Utah to study the origin, cause, and prevention of floods in Davis County. Part 1 deals with ways and means, part 2 with flood control works, and part 3 with causes and prevention of floods.

Evidence was observed on the watersheds of Davis County to show that had the plant cover been approximately equal to its original natural condition, the flooding in that section from the rains of 1930 wuold have been far less serious, if not prevented.

The commission recommended the construction of barriers and settling basins at the mouths of the flooded canyons as the best means to control the high water and the debris it will otherwise deposit on valuable property during the spring runoff period and summer freshets, and, in so far as possible, to control floods similar to those of 1930 pending the restoration of normal conditions on the watersheds. Rehabilitation and maintenance of the plant cover on the depleted parts of watersheds is necessary for the abatement or prevention of floods.

Data also are included on the geology of the area.

Sprinkler System of Irrigation, F. L. Overley, E. L. Overholser, and O. M. Morris (Washington College Station (Pullman) Bulletin 245 (1930), pp. 42, 43).—Experiments on the irrigation of orchards with sprinklers, conducted in cooperation with the U.S.D.A. Bureau of Plant Industry and the Washington Committee on the Relation of Electricity to Agriculture, showed that the same amount of water is necessary to saturate a soil whether applied by sprinklers or rill system of irrigation except for a difference in evaporation during extremely warm weather. On sandy soils with light subsoil and on sloping land, the proper amount of water could be applied with less waste by sprinklers than with the rill system.

With overhead sprinklers about a third less arsenate of lead was found on the fruit at harvest time as compared with the sprinklers under the trees.

Poultry Housing, M. W. Miller and J. S. Carver (Western Washington Station (Puyallup) Bulletin 18-W (1930), pp. 25-27).—The organization, procedure and equipment of a controlled poultry housing study at the station is briefly described. No appreciable temperature difference was recorded between straw loft and wooden ceiling. Drier conditions were found to exist on concrete floors laid on the ground than on concrete floors supported on a board floor from 6 inches to 3 feet from the ground. Apparently the value of solid partitions was demonstrated.

[Agricultural Engineering Investigations at the Mississippi Station], J. W. Carpenter, Jr. (Mississippi Station (A. and M. College) Report 1930, pp. 8, 9).—Cotton ginning tests made in cooperation with the U.S.D.A. Bureaus of Agricultural Economics and Public Roads emphasized the damage to fiber due to ginning with tight breast roll. The increased value of lint ginned with loose breast roll more than compensates for the decrease in capacity of the gin, which in some cases amounts to approximately 50 per cent. Wet cotton or sappy cotton may be successfully dried either by sunning, by heated air, or by cold air which has been chemically dehydrated. Cotton was dried successfully with air which had been dehydrated by passing through calcium chloride.

Construction of Chimneys and Fireplaces (U. S. Department of Agriculture (Washington, D. C.) Farmers' Bulletin 1649 (1930), pp. II + 18, figs. 16).—This is a revision of and supersedes Farmers' Bulletin 1230. It presents practical information on the planning and construction of fireplaces and chimneys.

Rice Farm Irrigation Systems in Louisiana, 1929, R. J. Saville (Louisiana Station (Baton Rouge) Bulletin 216 (1930), pp. 19).—The results of a survey of rice irrigation systems and practices in Louisiana during 1929 are reported.

The yield per acre of rice was slightly higher on farms using deep-well water, although it is considered doubtful that the water source is the determining factor in this connection. Two-thirds of the irrigation plants had Diesel engines. The usual size of Diesel engine has a capacity suited to flooding a larger acreage than prevails on many rice farms. The proportion of the farm investment in the irrigation plant varied from 20.5 per cent on the small farms to 10.3 per cent on the large farms.

Water rentals varied directly with yield per acre and the price of rice, usually amounting to one-fifth of the value of the crop delivered in the warehouse.

About 60 per cent of the farmers using Diesel engines flooded for the total outlay of from $5 to $10 per acre. Seventy per cent of them had operating outlays of less than $4 per acre. Farmers equipped to flood 400 acres were able to keep their total outlay down to about $6.50 per acre. Those operating from 101 to 200 acres had a total outlay of $10.38 per acre. Operating labor outlay tends to decrease as the area flooded is increased, because the total outlay for pumping labor increases very little after the pumping requires the attention of two full time men.

Electric motors are rapidly replacing Diesel engines as a source of power for irrigation purposes, although the latter can be operated at a much lower operating outlay than can electric motors. It is only when the Diesel engine must be overhauled or is worn out that other needed outlays are involved. The block rate for electrical energy consumption favored the large operator. Small operators were unable to take advantage of the lower range of rates because of low energy consumption.

Higher labor incomes were secured by farmers operating private irrigation plants. Much of the difference in income was due to the larger volume of business handled by them.

[Agricultural Engineering Investigations at the South Dakota Station] (South Dakota Station (Brookings) Report 1930, pp. 3-5).—Investigation of the windrower in connection with the combine study showed that in a clean field heavy windrows were not objectionable so far as drying out of the grain is concerned. There was less loss in picking up the grain at 2 miles per hour than when picking it up at 3 miles per hour with all sized windrows. This loss was very heavy on the larger sized windrows.

The combine threshed a swath of from 4 to 6 feet wider than its cutting width without loss in a field of oats yielding 52 bushels per acre. When the rate of travel was increased or the width of swath extended above this, the losses were increased both as to shattering and threshing. A fairly heavy windrow stayed in good condition for a period of a month, regardless of ordinary rains. Heavy windrows kept better than smaller ones as they stayed up on the stubble better.

In the study of corn harvesting machinery, it was found that the optimum diameter of the husking roll is between 3.5 and 4 inches, the optimum length of husking roll for a stationary husker is from 36 to 42 inches, the most satisfactory husking peg is a flat-headed stud, the optimum speed for husking rolls is 300 rpm, the optimum angle for the husking rolls in the bed is from 18 to 22 inches, and a machine allowing an adjustable angle to suit the moisture content in the husks of the snapped corn is desirable. One ear retarder at the top of the husking bed is most satisfactory.

The study of the use of rammed earth for farm building walls showed that a considerable amount of sand is necessary in dirt to be used for this purpose and that South Dakota soils generally are lacking in sand. The sand is necessary to absorb the shrinkage stresses as the block dries out. The allowable moisture content in soils varies inversely as the amount of sand in the soil.

A System for the Bacteriological Examination of Water, A. J. Salle (Journal of Bacteriology (Baltimore), 20 (1930), No. 6, pp. 381-406, fig. 1).—In a contribution from the University of California and the Bureau of Sanitary Engineering of the California Department of Public Health, the results of comparative tests are reported, using **B. coli, B. aerogenes, B. subtilis, Staphylococcus aureus,** and **S. albus.** These have shown the superiority of crystal violet over brilliant green as a bacteriostatic agent.

A crystal violet broth medium for the presumptive test is described, containing peptone (Difco) 15 gm., K_2HPO_4 15 gm., KH_2PO_4 3 gm., lactose 15 gm., crystal violet (1 : 5,000 solution) 21.5 cc., and distilled water to make 2,000 cc. Production of acid and gas in this medium in practically 100 per cent of the samples examined is due to members of the coli-aerogenes group. An agar-dye differential medium, containing peptone 10 gm., K_2HPO_4 3 gm., KH_2PO_4 0.6 gm., lactose 5 gm., agar 20 gm., distilled water 1,000 cc., erythrosine (2 per cent aqueous) 20 cc., mythylene blue (1 per cent aqueous) 20 cc., and bromcresol purple (1 per cent alcoholic) 2 cc., is described.

Results on this medium are equivalent to a partially confirmed and a confirmed test. In other words, two tests are obtained in one operation, thus shortening the period to complete an analysis by 24 hours. **B. coli and B aerogenes** are sharply differentiated because of distinct differences in their carbohydrate metabolism.

Results of water examinations are detailed, showing the superiority of the method over the standard method. It gives not only more clear-cut results due to elimination of interfering noncolon organisms, but also a saving of at least 24 hours in the time necessary to complete an examination.

A list of 86 references is included.

Timber Design and Construction, H. S. Jacoby and R. P. Davis (New York: John Wiley & Sons; London: Chapman & Hall, 1930, 2 ed., [rev.], pp. XII + 334, pls. 10, figs. 91).—This is the second, revised edition of this book. It contains the digested results of extensive experimental investigations and research on fastenings used in framing, including bolts, nuts, washers, spikes, nails, screws, dowels, pins, keys, and metal straps and plates. In the description of joints in framing, the principal types of tension joints are illustrated, and other types such as lap and scarf, bearing, dovetail, mortise and tenon, and step joints, angle blocks, and metal shoes are discussed. Other chapters deal with wooden beams, wooden roof trusses, examples of practice used in frame construction, and commercial grades, timber tests, and unit stresses.

Principles of Structure for Apple Storage Houses, J. B. Kelley (Kentucky State Horticultural Society (Lexington) Transactions, 1928, pp. 153-165, fig. 1).—In a contribution from the Kentucky Experiment Station, a discussion is presented of the fundamental principles involved in the design of an air-cooled apple storage house for Kentucky conditions. Special attention is devoted to the control of temperature, humidity, and ventilation and the design of insulation. A list of references to reports bearing on the subject is included.

Basic Principles of Concrete Making, F. R. McMillan (New York and London: McGraw-Hill Book Co., 1929, pp. XV + 99, figs. 32).—Following an introduction by F. E. Schmitt, this book presents the underlying principles of concrete mixtures. It contains chapters on the philosophy of concrete mixtures, combined and uncombined water, compressive strength, water-tightness and other properties, combining aggregates with cement paste, design of concrete mixtures, selection of curing period and water-cement ratio, selection of aggregates, and importance of proper construction methods.

Book Review

"Handbook of Concrete Construction" is the title of a pocket-size volume of information on materials, methods and engineering data for a wide variety of structures and uses, recently published by the Universal Atlas Cement Company. It is available at the general office of the company, 208 South LaSalle St., Chicago, or from any of its branch offices. $1.00.

AGRICULTURAL ENGINEERING

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Contributions of interest and value, especially on new developments in the field of agricultural engineering, are invited for publication in this journal. Its columns are open for discussions on all phases of agricultural engineering. Communications on subjects of timely interest to agricultural engineers, or comments on the contents of this journal or the activities of the Society, are also welcome.

Original articles, papers, discussions, and reports may be reprinted from this publication, provided proper credit is given.

RAYMOND OLNEY, Editor

R. A. Palmer, Associate Editor

The Anniversary Influence

THE Twenty-Fifth Anniversary Meeting of the American Society of Agricultural Engineers came fully up to expectations. It brought together more agricultural engineers than had ever assembled at one place and for one occasion in the western hemisphere, or possibly in the world. It gave us a glance at our profession's early years which filled us with pride, satisfaction and a new appreciation of our obligations. It showed us our recent progress and contemporary status—a scene which inspired confidence but was not so flattering as to breed complacency. It stretched back the horizon of the field, revealing new problems and opportunities. We left Ames with new ideas, new ambitions, new energy and an itch to be at work, bettering our past accomplishments.

International Agricultural Engineering Congress

AN INTERNATIONAL congress of agricultural engineering to be sponsored by the American Society of Agricultural Engineers and to be held in America in the summer of 1933, as approved by the Society in its business meeting, is a great undertaking.

It means officially inviting all interested foreign countries to send representatives and present papers. It means preparing to receive these representatives; being host to them; broadening the program of the annual A.S.A.E. meeting to make it of international interest; and broadening the arrangements to take care of increased attendance, differences in language and customs, and more than the usual number of trips to points of agricultural engineering interest. In short, it means doing everything in our power to make the presence of the visiting agricultural engineers mutually educational and pleasant.

But it will be well worth all it costs. The benefits of internationalism in science are well known. Internationalism in the professional applications of science is a newer but equally promising development. An international congress of agricultural engineering will promote world unity and world-wide progress in this field. The engineering problems of agriculture involve similar materials, processes, principles and data the world over. Although there are differences in angle of approach and in stages of development reached, the agricultural engineers of all countries have much to learn from each other to their mutual advantage. The A.S.A.E. will be more than repaid for sponsoring the congress by the opportunity afforded its members in the United States to come in contact with the leading agricultural engineers of other countries and to show them first hand our methods, equipment, accomplishments and unsolved problems.

While the sponsoring of this congress is a great responsibility, the A.S.A.E. is equal to it. A committee has been studying the proposition. Its recommendation and that of the Council represent mature judgment. The matter is decided and it is not too soon to begin planning the details. Neither is it too soon for individual members of A.S.A.E. to begin thinking, planning and preparing to contribute to the success of this congress and to share its benefits by their presence and their technical or other contributions.

Professional and Educational Standards

AT THE College Division session during the recent A.S.A.E. annual meeting, attention was focussed on the closely related problems of raising the standards of agricultural engineering education and of the profession.

Our profession has been severely criticized for not having more definite educational prerequisites. It has been blamed, with some justification, for use of the title "agricultural engineer" by some unqualified individuals.

Truly the educators have a problem in the matter of standards. They are training men for an exacting profession; one that is demanding supermen. The common clay which comes to them must in four or five years be given guidance, opportunity and encouragement in its start up the long road of development in capacity for knowledge, constructive thought and application of physical, chemical and biological sciences and the humanities or cultural subjects. Is it any wonder that there are differences of opinion as to where to start, how to proceed, and how far to go? At the same time the educators must give instruction in agricultural engineering subjects to agricultural students, some of whom may get the impression that, by virtue of such courses, they have become agricultural engineers. In the face of this situation the Advisory Committee of the College Division has done well to define agricultural engineering curricula.

But, while the professional course is becoming more and more the usual elementary preparation for becoming an agricultural engineer, this is by no means a closed profession. It does not involve public safety so directly that a bachelor's degree in agricultural engineering, or professional A.E. degree should be prerequisite to entrance. A degree is at best only a rough measure of the holder's abilities. There is no way of positively predicting the application, capacity and performance which an individual may show at some time in the future. Fitness for membership in a profession must, in the end, be based upon demonstrated qualifications rather than on preparation. Some of the leading agricultural engineers of today learned their engineering in the hard school of practical experience while others hold degrees in other branches of engineering. Even though the professional course in agricultural engineering has developed to where it is ordinarily the easiest and best road toward identification as an agricultural engineer, the profession should be held open to those who by choice or necessity have qualified themselves by other means.

The organized profession should take an active interest in improving engineering education, as recommended by L. W. Wallace in his paper presented during the business meeting. But it should exert an even more direct influence on professional standards through election to its membership. Following the precedent of many other professions, full membership in A.S.A.E. should be interpreted as recognition by the profession of the individual's right to call himself an agricultural engineer.

A.S.A.E. and Related Activities

A.S.A.E. Twenty-Fifth Anniversary Celebrated

AT ITS 25th anniversary meeting at Iowa State College, June 22 to 25, the American Society of Agricultural Engineers celebrated the twenty-fifth year of its existence, with a record attendance of its members and friends, a program of compelling interest, inspiring revelations of its progress, and the undertaking of momentous new responsibilities. The event amounted, in fact, to a rededication of agricultural engineers to their work of extending to agriculture the benefits of engineering.

A vanguard of agricultural-engineering instructors arrived at Ames the week previous to the meeting for a four-day conference on teaching methods. Registration of these and other arrivals for the A S A E meeting began at the Memorial Union building June 21 and continued through June 25, when the total registration of close to 450 topped last year's record attendance by a substantial margin. The attendance of more of the wives and families of the agricultural engineers was largely responsible for the increase.

S. P. Lyle, chairman of the Society's College Division, called this division session to order Monday morning, June 22; read a brief report of its Advisory Committee; and called for reports of its other committees. H. B. Walker presented a paper on agricultural engineering educational standards, and C. E. Seitz read the professional agricultural engineering curriculum recommendations of the Advisory Committee. A lively discussion which followed these presentations showed that in many aspects the curriculum problem is far from settled.

Simultaneous sessions of the Society's four technical divisions opened Monday afternoon as scheduled. Each of the division programs was carefully prepared, drew the attendance of a fair share of those present, and satisfied those who came primarily to imbibe technical information on the most recent developments in the four main branches of agricultural engineering.

The Land Reclamation Division program was built by Chairman L. F. Livingston upon a foundation of committee reports. The past year's work of the Division's committees, which had previously been mimeographed and sent to its members, were briefly reviewed and made the basis of discussion. Additional copies of the reports were available at the meeting and may now be obtained from the Society headquarters.

Dr. Elwood Mead, an honorary member of the Society, was the feature speaker on the reclamation program. In his address on the Hoover Dam he reviewed the history of the Southwest which led to the undertaking of this project; discussed its significance from the standpoints of flood control, water supply and power generation; and reported on the progress being made in spite of the great engineering difficulties which the project involves.

Progress reports of technical committees were also heard in the Power and Machinery Division meeting.

Dairy farm structures problems, the farm home, and structures research were the items to which the Structures Division gave most consideration in its three half-day programs.

During its three full half-day sessions the Rural Electric Division heard and discussed papers on research, extension, electrical distribution and a wide variety of rural applications.

At a dinner Monday evening the 1931-32 Meetings Committee considered plans for the annual meeting to be held next June at Ohio State University, as well as division meetings to be held during the year. The Council held a meeting at 8 o'clock the same evening.

At a student agricultural engineers session, also held Monday evening, 24 students from five schools, together with several faculty members and the Committee on Student Branches, discussed and approved certain proposed changes in Society policies and activities having to do with student branches and student members. Various students spoke briefly on the activites of their branches. H. B. Walker, head of the division of agricultural engineering, University of California, and E. W. Lehmann, head of the department of farm mechanics, University of Illinois, gave brief inspirational messages to the students out of their long experience as teachers.

An unusual number of important matters came before the Society at its business meeting Tuesday evening. President R. W. Trullinger, after calling the meeting to order, called upon Raymond Olney, secretary-treasurer of the Society, for comments on the reports of the secretary and of the treasurer which had previously been mailed to members of the Society. He called attention to the generally satisfactory state of the affairs of the organization. President Trullinger reported on the activities of American Engineering Council, on which body he is the representative of the Society. ciety.

J. B. Davidson, a charter member and first president of the Society, read a resolution honoring deceased A S A E members for the contributions of their active years in the profession. It was unanimously approved by a standing vote of those present.

In reporting for the Committee on Bureau of Agricultural Engineering, F. A. Wirt, chairman of the committee, pointed out that recent approval and organization of the U.S.D.A. Bureau of Agricultural Engineering should not end the Society's work in this direction. It and its individual members should now cooperate with and assist the Bureau in every way possible to insure its fulfilling the claims made for it.

Prof. C. H. Th. Denker, vice-president of the German Society of Agricultural Engineers, was present at the meeting with Nordahl Wallem, German agricultural engineer who is doing research work in agricultural economics at Montana State College, and extended the congratulations and best wishes of the German agricultural engineers to the A.S.A.E. He also invited American agricultural engineers to visit Germany and study its progress along this line.

President Trullinger reported that at its meeting the Council recommended that the Society sponsor an international agricultural engineering congress in 1933. Discussion revealed that there will be no world engineering congress that year and that the proposed agricultural engineering congress would take the place of the Society's 27th annual meeting. The recommendation of the Council was approved by vote of those present.

A gift of $10,000 to the Society by Cyrus H. McCormick, Mrs. Emmons Blaine and Harold F. McCormick, children of Cyrus Hall McCormick, the inventor of the reaper, to be used as the Society sees fit in recognizing outstanding work in agricultural engineering, was announced by President Trullinger. Col. O. B. Zimmerman, chairman of the committee on Medals and Awards, reported on the details of the endowment and plans for its use. Part of the money will be spent on the design and die for a gold medal to be known as the "Cyrus Hall McCormick Medal." The income from the remainder will be used in conferring the medal, with a cash award, to agricultural engineers selected to be honored.

President Trullinger next called upon President-Elect Leonard J. Fletcher for a few remarks. He emphasized the Society's function as a meeting ground; announced his intention of doing all in his power to raise the membership standards and to increase efficiency of committee work; and stated that he would attend every division and section meeting during the year.

In spite of the fact that the evening was extremely warm, the large audience which attended the business meeting remained to hear L. W. Wallace, executive secretary of American Engineering Council, deliver an address on engineering educational standards.

Anniversary Day, June 24, was ushered in by H. B. Roe, chairman of the Meetings Committee. After calling the morning session to order he introduced Dr. R. M. Hughes, president of Iowa State College, who delivered the address of welcome.

Other features of the morning session were "The President's Annual Address," by President Trullinger; "The Philosophy of Agricultural Engineering," by Dr. J. B. Davidson; "Fitting Engineering into the Agricultural Picture," by the Hon. L. J. Dickinson, U. S. Senator from Iowa; and "The Engineer's Responsibility to the State," by Anson Marston, dean of engineering, Iowa State College.

In the afternoon the audience retreated from its regular meeting room in the Memorial Union to Agricultural Hall to hear two addresses; "The Contribution of Land Reclamation to Agricultural Engineering Development," by James A. King; and "One Hundred Years of Development in Farm Machinery," by Cyrus McCormick, Jr.

In the latter part of the afternoon a field of half-ripened rye near the agricultural engineering building became the scene of a pageant portraying the evolution and development of grain-harvesting machinery. From a tier of bleachers at the west edge of the field the A.S.A.E. crowd and a still larger audience of Iowa farmers saw and applauded harvesting with sickles, sythes, cradles, and a series of reapers, binders and combines. The events were announced and explained from a loud-speaker in the center of the field. A model of McCormick's first reaper cut its four-foot swath down the field. Trouble with the wire binder added a touch of realism to the procession. Perhaps the most spectacular event was combining with an old wood-frame, ground-drive machine which has been in use almost continuously since 1887 and which has harvested more than a million and a quarter bushels of grain. Twenty-two mules untrained to the work gingerly drew the monster of wood and iron, guided by two drivers and men on foot, while the audience, warned of the possible danger of a runaway, looked on in awed silence. The modern machines showed up as fast, efficient, smooth wonders of performance compared with their predecessors.

The seventeenth and last event showed a man carrying a bushel of grain, the maximum output of one man-hour's work with cradle and flail; followed by a truck carrying 30 bushels of grain representing an output per man-hour easily obtained with a modern 12-foot combine; succeeded in turn by a procession of 12 cradlers, 12 hand binders and 48 flailers who would be required to do the work of two men and a modern combine. E. G. McKibben, associate professor of agricultural engineering, Iowa State College, arranged and directed the pageant.

Exhibits of agricultural engineering equipment, models and materials were also on display in the agricultural engineering building.

The concluding feature of the Anniversary Day program was the A S A E Annual Dinner, held in Great Hall of the Memorial Union. Toastmaster R. U. Blasingame directed a program including a presentation of charter members; an address by Howard Wait Riley; short talks by Cyrus McCormick, Jr., President Trullinger, and President-Elect Fletcher; and a few stunts. A dance followed the program.

Addresses which sustained interest throughout the Thursday morning program were "The Function of the Extension Engineer in the Reorganization of American Agriculture," by B. B. Robb; "Electricity and the Agriculture of the Next Ten Years," by Dr. E. A. White; "Training of Research Workers," by Dr. Andrew Boss; and "Probable Future Developments of Chemistry in Agriculture," by Dr. O. R. Sweeney.

Early in the afternoon those who wished were shown through Dr. Sweeney's corn by-products laboratory, in which corn stalks are transformed, on an experimental scale, into hundreds of different useful materials.

At two o'clock chartered busses were ready to take members and guests of the Society, as guests of the Meredith Publishing Company, for a trip to Des Moines. There they were shown through the Wood Brothers Thresher Company's factory and the Meredith Publishing plant, visited the Meredith farm and were given a lavish picnic supper on the estate of Mrs. E. T. Meredith.

The energetic rural electric project directors pushed through their annual session early Thursday afternoon in time to attend the picnic supper at Des Moines, rather than hold over for another day.

Thus ended the twenty-fifth anniversary meeting of the American Society of Agricultural Engineers. Its members scattered again to carry on with renewed vigor and understanding.

A report of the meeting, however, would not be complete without noting that G. W. McCuen, head of the department of agricultural engineering at Ohio State University, had his faculty present "en masse" and diligently studying the meeting in all its details in search of ways and means of making next year's meeting, to be held at Columbus, Ohio, even surpass the one this year. Wm. Aikenhead, head of the department of agricultural engineering at Purdue University, brought to the meeting a hopeful delegation from the LaFayette institution and a load of propaganda pointing out its advantages as a meeting place for the Society in 1933.

Resolutions passed by the Society were as follows:

WHEREAS the twenty-fifth anniversary session of the American Society of Agricultural Engineers, which has just come to a close, will go down in the history of our society, not simply because it marked the passing of twenty-five years of society activity, but also because of the outstanding merit of the meeting in all its phases, and

WHEREAS the historical pageant was unique in conception and execution and was educational and inspirational in its effect, therefore, be it

RESOLVED by this society in session assembled that we extend a unanimous vote of thanks and appreciation to all officers and committees for their part in making this meeting so replete with those things which will help to advance the worthy purposes of this society.

WHEREAS the Congress of the United States has seen fit to vote an appropriation to finance the activities of a Bureau of Agricultural Engineering created within the United States Department of Agriculture, with our distinguished fellow member, Mr. S. H. McCrory, in charge, therefore, be it

RESOLVED that this society in convention assembled, extend to the chief of that bureau and to his entire staff the assurance that this society, as such, and all its members, as individuals, stand ready and eager to cooperate with them in every way possible to make this bureau such a vital and effective factor in advancing the welfare of American agriculture, that the Congress of the United States, the Secretary of Agriculture, and the nation as a whole, will realize that the establishment of that bureau and the placing of Mr. McCrory in charge of it were acts of wisdom.

WHEREAS the conduct of the affairs of this society during the trying year which has just closed has resulted in an increase of membership, an improvement of our financial condition, and a journal of improved merit, and

WHEREAS these results are due more to the efforts of Raymond Olney, our secretary-treasurer, than to the efforts of any other individual, therefore, be it

RESOLVED that we hereby extend to Raymond Olney our thanks and appreciation for the effective administration of the affairs of his office.

WHEREAS Mr. Cyrus H. McCormick, Mrs. Emmons Blaine, and Mr. Harold F. McCormick, children of Cyrus Hall McCormick, the inventor of the reaper, have given to the American Society of Agricultural Engineers a fund of $10,000 as a foundation, the income from which is to be used each year in making, on behalf of this society, an award of merit as recognition to the individual who during the preceding year has rendered the most outstanding service to the nation in the field of agricultural engineering, and

WHEREAS this foundation and its proper administration will be of material assistance in furthering the purpose, ideals and aims of this society, therefore, be it

RESOLVED that the American Society of Agricultural Engineers in convention assembled hereby extend to the donors

of this foundation the unanimous thanks and appreciation of this society and its individual members for this foundation fund, and for the constructive purpose which they had in mind when giving it.

The following resolution was adopted by the Land Reclamation Division of the Society:

WHEREAS Land Reclamation involves putting agricultural land to that use in which it will render the largest possible benefits to both the owner and the general public—whether this be the production of crops or the furnishing of recreation—and increasing the benefits to be obtained by the proper use of that land to the highest point commensurate with the cost involved; and

WHEREAS the farm home and its surroundings, together with the proper planning and grouping of buildings, arrangement of fields, selection and use of equipment constitute an important factor in the land utilization of reclamation, therefore, be it

RESOLVED that the Land Reclamation Division of American Society of Agricultural Engineers hereby suggests that future reclamation projects be planned and constructed with due consideration given to these items and their relation to the successful development and operation of the project, and be it further

RESOLVED that copies of this resolution be sent to the U. S. Bureau of Reclamation, U. S. Bureau of Agricultural Engineering, Deans of Agriculture, Heads of Departments of Horticulture and Agricultural Engineering, and to the agricultural development officials of the American and Canadian railroads.

New Bureau Swings Into Action

THE Bureau of Agricultural Engineering, U.S.D.A., officially began its existence July 1 with S. H. McCrory as chief. Mr. McCrory has for several years past headed the agricultural engineering work of the Department under its former status as a division of the Bureau of Public Roads.

Secretary of Agriculture Arthur M. Hyde in officially announcing the advent of the Bureau and the appointment of Mr. McCrory as its chief, briefly explained the attitude of the Department toward agricultural engineering as follows:

"The importance of sound engineering practice as a factor in modern agriculture has made the creation of a new bureau necessary.

"Agricultural engineering is one of the younger professions and its importance is steadily increasing. The engineering work of the department has dealt with irrigation, drainage, soil-erosion control, farm mechanical equipment, and farm structures. The high efficiency of American agriculture has been in a great measure the result of the rapid development of farm machinery, and agricultural engineering has been instrumental in this development.

"The growing problem of the prevention and control of soil erosion has opened an important field for the agricultural engineer. Agricultural engineers of the department have taken a large part in the development of the irrigation and drainage practices of today. The improvement of farm structures is another field that is of growing importance.

Samuel Henry McCrory

"With all these activities expanding, it has been deemed highly desirable that the Department of Agriculture include in its organization a strong agricultural engineering bureau.

"It is hoped to make the new bureau serve the needs of the family farm, rather than the more spectacular mass-production farm."

Engineering Index Service Growing

ENGINEERING Index Service, sponsored by the American Society of Mechanical Engineers and aided by the cooperation of the Engineering Societies Library, has grown since its inception in 1884, until it now covers 223 divisions of engineering subject matter and application.

New engineering publications arriving at the library in an almost continuous stream from all parts of the world are reviewed by a staff of engineers and an annotated index card prepared. Approximately 50,000 separate articles are now being indexed each year. The indexes are printed on index cards sent out regularly to subscribers to the service. They are also printed in a complete volume of more than 2000 pages at the end of the year.

One may subscribe to any one or more of the 223 divisions of the card service. There is a division on agricultural engineering, covering general and miscellaneous agricultural engineering subjects not otherwise classified, including agricultural chemistry manufacture and use of agricultural machinery, farm buildings and farm management. The articles appearing in AGRICULTURAL ENGINEERING are among those indexed in this service. The subscription price to this division is $9.00 per year. Complete service, covering all divisions costs $1500 per year.

Together with the photoprint and translation services of the Library the Index places current engineering literature at the disposal of anyone, anywhere. The cards give current notice of the latest ideas, methods, experiences and achievements in engineering. The annual volumes are encyclopaedic bibliographies of the current engineering literature of the world.

An announcement of the different divisions available, with the subscription price of each, may be had by addressing The Engineering Index Service, Engineering Societies Bldg., 29 West 39th St., New York, N. Y.

North Central Section Holds Business Meeting

ON Monday evening, June 22, members of the North Central Section who were attending the Society's Anniversary meeting at Ames were called together by J. Grant Dent, secretary-treasurer of the Section, for a short business meeting.

The minutes of the 1930 meeting were read and accepted. A financial report showed that the Section has $65.34 on deposit. In the line of new business the matter of section meetings was discussed. A consensus of opinion of those present favored discontinuing the holding by the section of a regular annual technical meeting, substituting therefor meetings called at such times as may be deemed advisable. Decision as to whether or not the Section should hold a meeting next year was left to the incoming officers.

The nominating committee in its report named as candidates for offices in the Section, the following: James A. King, chairman; E. G. McKibben, 1st vice-chairman; G. E. Martin, 2nd vice-chairman; J. G. Dent, secretary-treasurer; and C. W. Smith, F. C. Fenton, and E. V. Collins, nominating committee. No other nominations were submitted and those present voted to cast a unanimous ballot for the nominees.

Following the election the Section adjourned.

Land Reclamation Reports Available

ADDITIONAL copies of Land Reclamation Division Committee reports which were given distribution before and during the Twenty-fifth Annual meeting of the A.S.A.E. are now available at the Society Headquarters. They are reports of the committees on Soil Erosion Control; Run-Off from Agricultural Lands; Land Drainage; and Irrigation.

Copies of the general session paper by James A. King, entitled, "The Place and Function of Land Reclamation in the Agricultural Program," are also available.

Personals of ASAE Members

Hobart Beresford, head of the department of agricultural engineering, University of Idaho, and secretary and project director for the Idaho Committee on the Relation of Electricity to Agriculture, has published the seventh annual progress report of the Committee. It includes brief reports on investigations on water pumping, water heating, "V" belt drives, electricity in poultry production and use of ultra-violet light in agriculture.

F. D. Cornell, Jr., assistant professor of farm mechanics, West Virginia University, is author of West Virginia Agricultural Experiment Station Bulletin 239, entitled "Stationary Spray Systems in West Virginia."

R. C. Cosgrove was recently promoted to the position of rural distribution manager, merchandising department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania. Previous to this appointment he was manager of the company's small electric plant and water system sales.

A. W. Clyde has been appointed research agricultural engineer at the Pennsylvania State College. He formerly held the position of extension associate professor of agricultural engineering at Iowa State College.

W. C. Harrington has just been appointed extension agricultural engineer at Massachusetts State College Amherst. He was previously a field agricultural engineer for the Portland Cement Association.

George W. Kable, director of research for the Committee on the Relation of Electricity to Agriculture, is the compiler of a report on farm electrification research which the Committee has published as C.R.E.A. Bulletin, Vol. VI, No. 1.

H. F. McColly is author of North Dakota Agricultural Experiment Station Bulletin 245, entitled "The Harvester-Stacker Method of Harvesting Grain in North Dakota." He is also a joint author of Bulletin 244, entitled "Control of Quack Grass by Tillage."

T. A. H. Miller, agricultural engineer, Bureau of Agricultural Engineering, U.S.D.A., is author of Farmers' Bulletin No 1660, entitled "The Use of Logs and Poles in Farm Construction."

H. E. Murdock, agricultural engineer, Montana Agricultural Experiment Station, is author of Bulletin No. 243 of that station, entitled "Mechanical Tests on Tractor Farming Equipment." It is a progress report of tests conducted on the Lone Warrior tractor experimental farm in northeastern Montana.

B. B. Robb, professor of agricultural engineering, Cornell University, is joint author with F. B. Wright of Cornell Extension Bulletin 204, entitled "Electric Wiring for the Farm."

Necrology

Arthur Henry Hoffman, a member of the Society since 1914, passed away suddenly and unexpectedly May 19, at a hospital in Sacramento, California, where he had been confined for two weeks with an ear infection. In his native state of Iowa he earned his bachelor of arts degree at Iowa Wesleyan University, taught for several years in the public schools; earned a master of arts degree, also at Iowa Wesleyan, and a bachelor of science degree in electrical engineering at Iowa State College; taught physics and electrical engineering at Iowa State College, and conducted research in wireless telegraphy; and earned a bachelor's degree in agricultural engineering and a professional degree in electrical engineering, both at Iowa State College. Then he was for several years lecturer in agricultural engineering at Rutgers University three months of the year and conducted independent agricultural engineering research the remainder of the time. From New Jersey he went to New Mexico State College to become assistant professor of agricultural engineering. In 1919, J. B. Davidson, then head of the division of agricultural engineering at the University of California, called him to become assistant professor of agricultural engineering at that institution. This connection he maintained until the time of his death, having for the past several years been agricultural engineering research specialist in the agricultural experiment station. He will be remembered by agricultural engineers for his studies on air cleaners, oil filters, orchard heaters, tractor hitches, wearing of tillage implements and numerous other researches. He had served on the Council of the Society, was a member of its committee on research, and also was active in scientific, educational, civic, religious and other engineering organizations. In his passing the Society has lost a research leader, teacher, gentleman and friend.

New ASAE Members

N. R. Bear, instructor, Ohio State University, Columbus, Ohio.

Frank Daybell, owner, Daybell Laboratory, Porterville, Calif.

J. P. Seaholm, experimental engineer, Minneapolis-Moline Power Implement Company, Moline, Ill.

W. E. Street, instructor, Texas Technological College, Lubbock, Tex.

C. L. Svensen, professor of agricultural drawing, Texas Technological College, Lubbock, Tex.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the May issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

J. C. Archer, farm-foreman, U. S. Department of Agriculture, Lindale, Tex.

Gust Olson, Jr., general works manager, Oliver Farm Equipment Company, Chicago, Ill.

Hans Sack, diplom-Ingenieur, Rud Sack, Leipsiz W. 31, Germany.

EMPLOYMENT BULLETIN

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only Society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available" section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested. Copy for notices must be received at the headquarters of the Society not later than the 20th of the month preceding date of issue. The form of notice should be such that the initial words indicate the classification. There is no charge for this service.

Men Available

AGRICULTURAL ENGINEER with degree from Iowa State College 1925 and special work in farm structures desires to make change to more active work. Has several years experience in farm structures work with barn equipment concerns. Interested in making a connection with building materials manufacturer or promotion association, experimental station with state college, or barn equipment manufacturer. Age 38. Married. Location in Middle West preferred. MA-195.

AGRICULTURAL ENGINEER, with three years of teaching experience in the agricultural engineering division of a leading state university and recent experience in teaching agricultural mechanics in a high school, desires a position where he can continue his engineering training. Age 37. Married and has two children. MA-198.

AGRICULTURAL ENGINEER, 1917 graduate Iowa State College, licensed civil and professional engineer, 10 years experience in sales promotion and extension problems in both the agricultural and engineering fields, desires position in sales promotion, research or extension work. Best references, age 38, married. MA-199.

Positions Open

INSTRUCTOR IN FARM MECHANICS in a vocational agricultural school in New York state. PO-176.